Examiners' Report
Lead Examiner Feedback

January 2022

Pearson BTEC Nationals
In Applied Science (31627H)
Unit 5: Principles and Applications of Science II

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January 2022
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Grade Boundaries

What is a grade boundary?

A grade boundary is where we set the level of achievement required to obtain a certain grade for the externally assessed unit. We set grade boundaries for each grade, at Distinction, Merit and Pass.

Setting grade boundaries

When we set grade boundaries, we look at the performance of every learner who took the external assessment. When we can see the full picture of performance, our experts are then able to decide where best to place the grade boundaries – this means that they decide what the lowest possible mark is for a particular grade.

When our experts set the grade boundaries, they make sure that learners receive grades which reflect their ability. Awarding grade boundaries is conducted to ensure learners achieve the grade they deserve to achieve, irrespective of variation in the external assessment.

Variations in external assessments

Each external assessment we set asks different questions and may assess different parts of the unit content outlined in the specification. It would be unfair to learners if we set the same grade boundaries for each assessment, because then it would not take accessibility into account.

Grade boundaries for this, and all other papers, are on the website via this link:
http://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html

Awarding BTEC qualifications in 2022

Ofqual has set out their plans for awarding qualifications in 2022 and intend to return to a normal, pre-pandemic, approach to grading standards over by 2023. They have confirmed that 2022 will be a transition year, to reflect that we are in a pandemic recovery period and students' education has been disrupted.

Our guiding principle and approach to awarding BTEC qualification results in 2022 will be to ensure parity in relation to the approach being taken for GCSE and A level learners. BTEC courses have a different structure and design to academic qualifications - BTECs are modular qualifications (with assessments taking place throughout the course) compared to GCSEs and A levels which are linear (assessed and awarded at the same time at the end of the year), and therefore our approach needs to be different.

In 2022 we will return to the usual method of calculating BTEC qualification results, however adaptations including, U-TAGs and reduced internal assessment, are in place to provide a comprehensive package of support for students.

The basis of our awarding approach to BTECs this year is to ensure it is as fair as possible for all learners. We will use a range of evidence to set grade boundaries for the external units. Part of this evidence will be to closely monitor learner performance in all assessments that contribute to learners' final qualification grade, to ensure parity with A level and GCSEs.

Further information can be found on our website and via our Social Media channels.

Unit 5: Principles and Applications of Science II

Grade	Unclassified	Level 3			
		N	P	M	D
Boundary Mark	0	16	33	54	75

Introduction

Biology

31627_H1B is the biology section of the externally assessed Unit 5. This unit, Organs and Systems, covers the cardiovascular system (B.1), the respiratory system (ventilation and gas exchange in the lungs) (B.2), the structure and functions of the urinary system (B.3), and cell transport mechanisms (B.4).

This was the eighth series of the new specification. It was the fifth time that learners had sat the Biology, Physics and Chemistry sections as individual papers.

The question paper followed the same format as for the previous papers and for the sample assessment material. It consisted of five questions, four of which consisted of smaller items; there were 18 items in total. These included four multiple choice items and three other single mark questions testing mainly recall of knowledge. There were some 2, 3 and 4 mark items, each carrying a greater cognitive demand, where learners had to analyse or interpret information or apply their knowledge to a new scenario. These questions were marked using a points-based mark scheme.

The last question carried 6 marks and was marked using a levels-based approach that considered the overall quality of the response and not just the amount of correct and relevant facts presented by the learner. More detail can be found below, in the individual question section of the report.

Introduction to the Overall Performance of the Unit

Many learners were well prepared by their Centres, for the examination; they read the questions carefully with due consideration of the command word used and subsequently selected relevant and appropriate information to use in their responses.

However, a significant number, for some questions, did not sensibly use the information in the question stem. This type of omission was seen particularly in responses to Q2d where learners were asked why an amoeba does not need specialised structures for gaseous exchange. They should have been cued in as Q2a was about the structure of the cell surface membrane and Q2(b) – Q2(c) were about the amoeba. They were given a photomicrograph of an amoeba and some

information about it – that it is a single-celled eukaryotic organism that lives in fresh water; that water enters though its cell surface membrane and is collected into a contractile vacuole that moves to the cell surface membrane, fuses with it and then the excess water leaves the cell. Learners were asked to fill in gaps and thus to state how this water enters (by osmosis) and leaves (exocytosis) the cell. Many learners answered this part quite well and also then correctly identified the process of maintaining this water balance as osmoregulation and also deduced that the many mitochondria were needed to provide the energy needed to move the contractile vacuole.

A small number of learners, when then asked why this organism does not need specialised structures, such as alveoli, for gaseous exchange did not use the knowledge gained from the previous question. Some said it was a prokaryote or said it was non-living and so did not need to respire – ignoring the information that it was a eukaryotic organism, which lives in fresh water and that it has many mitochondria. However, many used the information and said it was small and so had a large surface area to volume ratio and that simple diffusion across its surface could supply enough oxygen, which did not have far to travel to reach the mitochondria and be used to release enough energy for its needs. Some learners think that mitochondria are for anaerobic respiration or perhaps they are confusing the terms aerobic and anaerobic.

Some of the responses to very straightforward questions, such as Q3(a) - drawing arrows on a diagram of a heart in section to show direction of blood flow through the left side of the heart, were disappointing. Learners are expected to know that in anatomical diagrams, seen from the ventral surface, the left side of the structure is on the right side of the page/diagram. They should also know that blood travels from atrium to ventricle. However, a surprising number showed the paths of blood on the right side of the heart and a significant minority showed blood flowing from ventricle to atrium or flowing from left to right side of the heart.

Introduction

Chemistry

This is the seventh examination series for the Unit 5 (Principles and Applications of Science II) Chemistry: Properties and uses of substances. The following topics were covered:

- **Question 1:** the extraction of aluminium from aluminium oxide (A1); the properties of aluminium oxide (its amphoteric nature and resistance to heat) (A1)
- **Question 2:** standard conditions (A3); standard enthalpy change of formation and use in the calculation of an enthalpy change (A3); the production of hydrogen by electrolysis (A1)
- **Question 3:** naming and drawing skeletal formulae (A2); geometric stereoisomerism (A2); conditions and products of cracking, and uses of the products (A2); drawing a polymer (A2)
- **Question 4:** understanding reaction profile diagrams and the effect of catalysis (A3); vanadium(V) oxide as a catalyst in the Contact process and its behaviour in terms of redox (A3)
- **Question 5:** comparison of the different reactions of ethene and ethane to produce chloroethane (A2)

Introduction to the Overall Performance of the Unit

In general, learners performed similarly on this paper by comparison to recent series.

Areas where learners performed well were:

- Identifying the method of extraction of aluminium - Q1(a)
- Identifying values of standard conditions of temperature and pressure - Q2(a)
- Calculating enthalpy change using standard enthalpies of formation – Q2(c)(i)
- Identifying a compound in solution that can be electrolysed to manufacture hydrogen gas – Q2(c)(ii)
- Identifying short-chain alkanes as products of cracking and their uses –

Q3(b)(i) and (ii)
- Identifying endothermic and exothermic enthalpy changes from a reaction profile diagram – Q4(a)
- Making comparisons between free radical substitution and electrophilic addition reactions – Q5

Areas where learners did **not** perform as well were:

- Explaining the properties of aluminium oxide / ionic compounds – Q1(c)
- Explaining why elements have a standard enthalpy change of formation of 0 kJ mol^{-1} – Q2(b)
- Naming and drawing skeletal formulae of alkenes – Q3(a)(i) and (ii)
- Conditions used for increasing the yield of alkenes in the product mixture from cracking – Q3(b)(iii)
- Drawing the polymer poly(propene) – Q3(b)(iv)
- Drawing reaction profile diagrams – Q4(b)
- Explaining catalysis in terms of reduction and oxidation – Q4(c)
- Explaining differences and similarities between free radical substitution and electrophilic addition reactions – Q5

Physics

Introduction to the Overall Performance of the Unit

Compared to the January 2021 series, learners performed at around the same level on the Physics paper. Learners were able to show a range of skills and some knowledge across a wide variety of specification points.

Learners' mathematical skills remain good in answers to calculation questions. Learners were able to access the calculations on the paper, the questions where mathematical skills were tested were, Q2(b)(i) & (ii), Q3(b)(i) & (ii), Q4(c)(ii). Of these Q2(b)(i) & (ii) scored well. There remain some aspects of mathematical skills that are problematic, for example rearranging equations, converting between units, using decimals sensibly or handling standard form in calculations correctly.

Some learners scored less well in some calculations because of significant power of ten errors that came about from not checking their working and learners not really being aware of scale of size. This has been a challenge to learners in previous series and it remains the case. It would greatly help learners if centres explained to students what the size of some physical quantities were, so that learners were aware of what the conversion was from g was in kg (Q3(b)) or km to m (Q2(b)). Many learners failed to score full marks due to not converting these quantities.

The use of some command words remains a challenge to learners. In particular the command 'explain'. This requires an identification and some form of expansion to score full marks. Learners were better able to provide complete answers to commands such as 'state' or 'calculate' and 'describe'.

Learners continue to find recalling information from the specification more of a challenge in this paper. Learners were not able to show that they understood the idea of turbulent flow in Q1(a). In Q3(a)(ii) the recall of the idea of thermal equilibrium was not well understood and in Q4(b) the concept of the movement of energy in elastic hysteresis was poorly understood.

The examination covered a wide range of topics from the specification and included some areas that were identified in the additional guidance for Unit 5. Areas where learners showed good knowledge and understanding, were in section C2 'Materials in domestic and industrial applications and some parts of C1 'Thermal physics in domestic and industrial applications.' Areas where learners struggled to provide answers were in sections C1 'Thermal physics in domestic and industrial applications' in the section relating to internal energy and thermodynamics and in section C3, the section relating to fluid flow and pressure related to fluid flow and viscous drag.

As in previous series several misconceptions relating to physical laws and principles remains. For instance, many learners were confused as to where the fluid pressure would be greatest in a pipe and the direction of viscous drag in Q1(b)(iii) & iv. In Q3(a)(ii), the idea that as temperature rises viscosity falls, many learners thought that the viscosity increases. In Q3(b)(i) many learners struggled to give a description of the change in particle arrangement in a solid and a liquid. Some learners remain unfamiliar with the meanings of some symbols in equations. For example, in the relationship $Q = m\ c\ \Delta T$ was used in Q3(b)(ii) by

some learners, despite being given the equation they had to use in the stem of the question learners mixed up the meanings of Q and L in this question also.

In the next part of this question, Q3(b) learners had to complete a table showing thickness of the walls of the left atrium, left ventricle and right ventricle. They were given wall thickness values to choose from. Most did get this right, but a surprising number think the right ventricle wall is thicker than the left wall, despite the information being on the diagram and the relevant chambers being labelled with letters given in the table, thus these learners were failing to apply information.

Individual Questions

Biology

Question 1

Question 1 focussed on the kidney – mainly the structure of the nephron and the functions of various parts of it.

Q1(a)(i) (1 mark)

For this question learners were given a diagram showing parts of a nephron, its blood supply and associated vessels and the collecting duct. Some parts were labelled and learners were asked to identify a structure labelled A, which is the glomerulus. Many learners correctly identified this structure and we accepted phonetic spelling. Some called it a knot of capillaries which is fine, but a few thought it was arterioles and some guessed loop of Henle or just gave nephron as their response.

Q1(b) (2 marks)

In this question learners were asked to show the functions of the PCT and the renal vein. The full name of the PCT was given on the diagram of the nephron, which was on the facing page so learners could see where the PCT is in the nephron which should help them recall its function. The renal vein was also shown in the diagram. Most learners correctly recalled the function of the PCT as selective reabsorption or they described it as reabsorbing glucose/amino acids/salts/ions or a named ion which were acceptable responses.

Reabsorbing water was also acceptable as although much of the water is reabsorbed from the collecting duct, some water is reabsorbed in the PCT.

Most learners identified the function of the renal vein as to carry blood away from the nephron or to the general circulation/to the vena cava. To carry blood to the heart was accepted as learners are not expected to know names of all major blood vessels but only to appreciate that veins carry blood to the heart. Some said to carry blood away from the nephron/kidney which is fine and some specified that it would be detoxified/filtered blood which was a good response.

This response gained 2 marks

(b) Table 1 shows the functions of some parts of a nephron.

Complete Table 1 to show the functions of the PCT and the renal vein.

(2)

Region of nephron	Function
PCT	Reabsorption of glucose
A	ultrafiltration of blood
collecting duct	reabsorption of water
renal vein	carry deoxygenated blood to the heart.

Table 1

Lead Examiner comment: *The learner has given a correct function for the PCT and for the renal vein.*

This response gained 1 mark

Region of nephron	Function
PCT	selective reabsorption
A	ultrafiltration of blood
collecting duct	reabsorption of water
renal vein	carries oxygenated blood around nephron / to away

Table 1

Lead Examiner comment: *The learner has correctly identified selective reabsorption as the function of the PCT. However, carries deoxygenated blood, although not an incorrect statement, is not enough for the function of this particular vein. It applies to most veins. Had they added 'away from the nephron', that would have achieved the second mark.*

This response gained 0 marks

Region of nephron	Function
PCT	absorption of ions and ~~wastes~~ blood etc.
A	ultrafiltration of blood
collecting duct	reabsorption of water
renal vein	deoxygenated blood leaves ~~send deoxygenated blood leaves the kidney~~ to go to the urethra urea and.

Table 1

Lead Examiner comment: *The learner has given a correct function for the PCT but then followed it with an incorrect response as blood is not reabsorbed. Thus, there is a list here, leaving the examiner to choose the correct response. The response for the renal vein function would have been fine had they simply said deoxygenated blood leaves the kidney (in it) but by giving further incorrect information this mark was also lost.*

Q1(c) (1 mark)

This was a short answer question asking learners to state the name of the hormone responsible for regulating the absorption of water from the collecting duct. Many learners gave the correct answer of ADH or antidiuretic hormone. Vasopressin would also have been accepted. Some appeared to not know this and gave the name of any hormone they knew, such as insulin. Some confused ADH with aldosterone that helps regulate salt content of the blood.

Q1(d) (2 marks)

Learners were told that the diameter of the efferent arteriole is smaller than that of the afferent arteriole. They were guided to look at the diagram given at the beginning of the question, to show where these two arterioles are.

Learners were asked to explain how the difference in the diameters aids the process of ultrafiltration.

Many learners correctly stated that it increased the pressure but then failed to get the second mark because they simply repeated the stem of the question by saying 'and so helps ultrafiltration' or 'helps filtration'. For the other mark they should have referred to small molecules or plasma/fluid being forced/pushed out of the capillaries in the glomerulus. Some did have the right idea but lost the mark by referring to blood being forced out or large proteins being forced out. Some gained a mark by describing the bottle neck effect or by using the term 'bottleneck effect'.

This response gained 2 marks

(d) The efferent arteriole, in structure **A** in Figure 1, has a smaller diameter than the afferent arteriole.

Explain how the difference in diameters helps the process of ultrafiltration.

(2)

The difference in diameters causes a high blood pressure and pushes the fluids out to the glomerulus.

Lead Examiner comment: *Although the blood pressure in the afferent arteriole is already high (compared to that of veins) and we would ideally have liked to see a reference to increasing the blood pressure or making it higher, this response was deemed acceptable and gained two marks. Causing high pressure and forcing fluids out implies that the pressure has been further increased (mp1) and forcing out fluids gains a second mark.*

This response gained 1 mark

(d) The efferent arteriole, in structure **A** in Figure 1, has a smaller diameter than the afferent arteriole.

Explain how the difference in diameters helps the process of ultrafiltration.

(2)

Because it can force the ~~blood water~~ minerals and urea out from the blood and into the bowmans capsule ~~(Glomerus)~~

Lead Examiner comment: *Here the learner has not made a reference to increasing pressure but has correctly stated what is being forced out of the glomerulus during ultrafiltration.*

This response gained 1 mark

(d) The efferent arteriole, in structure **A** in Figure 1, has a smaller diameter than the afferent arteriole.

Explain how the difference in diameters helps the process of ultrafiltration.

(2)

It helps by creating high pressure so the blood is forced into the glomerus, ~~meaning all~~

Lead Examiner comment: *Here the learner correctly states that high pressure is created and has referred to forcing but the wrong substance is being forced so this gains just 1 mark.*

This response gained 0 marks

(d) The efferent arteriole, in structure **A** in Figure 1, has a smaller diameter than the afferent arteriole.

Explain how the difference in diameters helps the process of ultrafiltration.

(2)

The higher the diameter, the more ultrafiltration will be produced. ~~If~~ A higher diameter ~~does~~ decreases the pressure of the blood, ~~etc~~ giving the process time to take place

Lead Examiner comment: *The first part of the response simply reiterates what is in the stem of the question and the next part is incorrect as it refers to decreasing the pressure and giving more time for the process to take place. The learner is referring to exchange at capillary beds in other organs of the body and not to the glomerulus.*

Q1(e) (2 marks)

This question asked learners to compete a short paragraph about the function of the loop of Henle. The two missing words we expected to see were electrolytes or salts or ions or named ions or just salt, and blood or capillaries.

Most learners achieved the first mark and a common response was salt. The second mark was more difficult to obtain and although some learners did correctly identify blood or a suitable blood vessel, some gave vague answers such as water. A few learners gave a very good response of vasa recta or referred to the extracellular or interstitial fluid, which showed excellent knowledge and understanding.

This response gained 1 mark

(e) Paragraph 1 describes some other functions of the nephron.

> The function of the loop of Henle is to create a very high concentration of .....**B**..... in the tissue fluid of the kidney.
>
> This high concentration causes water to leave the collecting duct.
> The water then enters the .....**C**..... .

Paragraph 1

Identify the missing words **B** and **C** in Paragraph 1.

(2)

B Water Salt

C .....

These responses gained 2 marks

Identify the missing words **B** and **C** in Paragraph 1.

(2)

B salt

C blood system

Identify the missing words **B** and **C** in Paragraph 1.

(2)

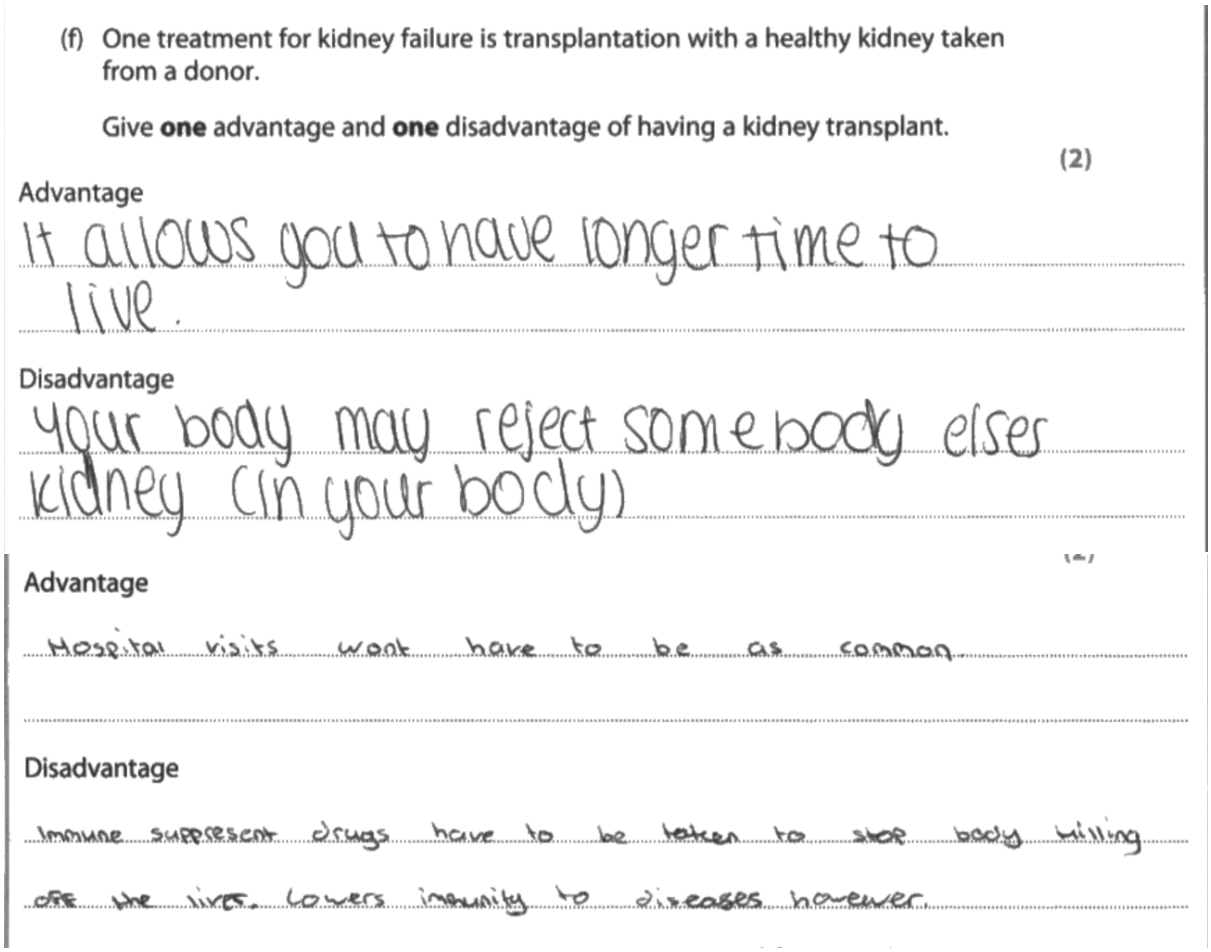
B Water Na^+

C Blood

Q1(f) (2 marks)

Learners were asked to state one advantage and one disadvantage of having a kidney transplant.

These responses gained 2 marks



(f) One treatment for kidney failure is transplantation with a healthy kidney taken from a donor.

Give **one** advantage and **one** disadvantage of having a kidney transplant.

(2)

Advantage

It allows you to have longer time to live.

Disadvantage

your body may reject somebody elses kidney (in your body)

Advantage

Hospital visits wont have to be as common.

Disadvantage

Immune suppresant drugs have to be taken to stop body killing off the liver. Lowers immunity to diseases however.

Lead Examiner comment: *We assume that the reference to hospital visits is in the context of dialysis.*

Most learners achieved 2 marks for this question. In the rare case where they did not, they had either identified two advantages or two disadvantages, left one option blank or gave incorrect information such as saying that a transplant was more expensive/less cost effective than dialysis.

Question 2

Question 2 focussed on transport mechanisms across membranes and the significance of size and surface area: volume ratio in living organisms.

Q2(a) (1 mark)

This was a multiple-choice question and learners were asked to select the correct diagram that showed the structure of the cell surface membrane according to the fluid mosaic model.

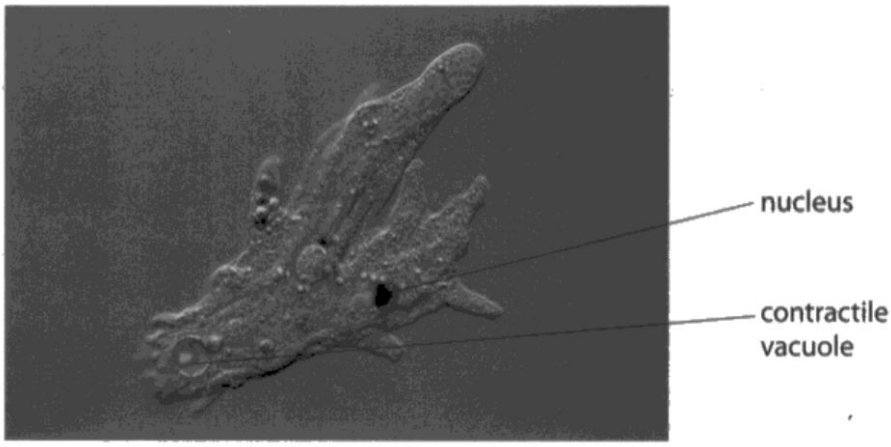
Most learners correctly identified option D, which showed a phospholipid bilayer with the hydrophobic tails facing inwards and containing an intrinsic and extrinsic protein molecule.

Q2(b)(i) (2 marks)

Learners were given a photomicrograph and information about a single-celled eukaryotic organism, *Amoeba proteus*, that lives in freshwater. They had information in the form of a flow chart that said water enters across the cell surface membrane, down a water concentration gradient by X, excess water is stored in a contractile vacuole that then moves towards the cell surface membrane, fuses with the cell surface membrane and then water leaves the cell by Y.

Learners were asked to identify processes X and Y.

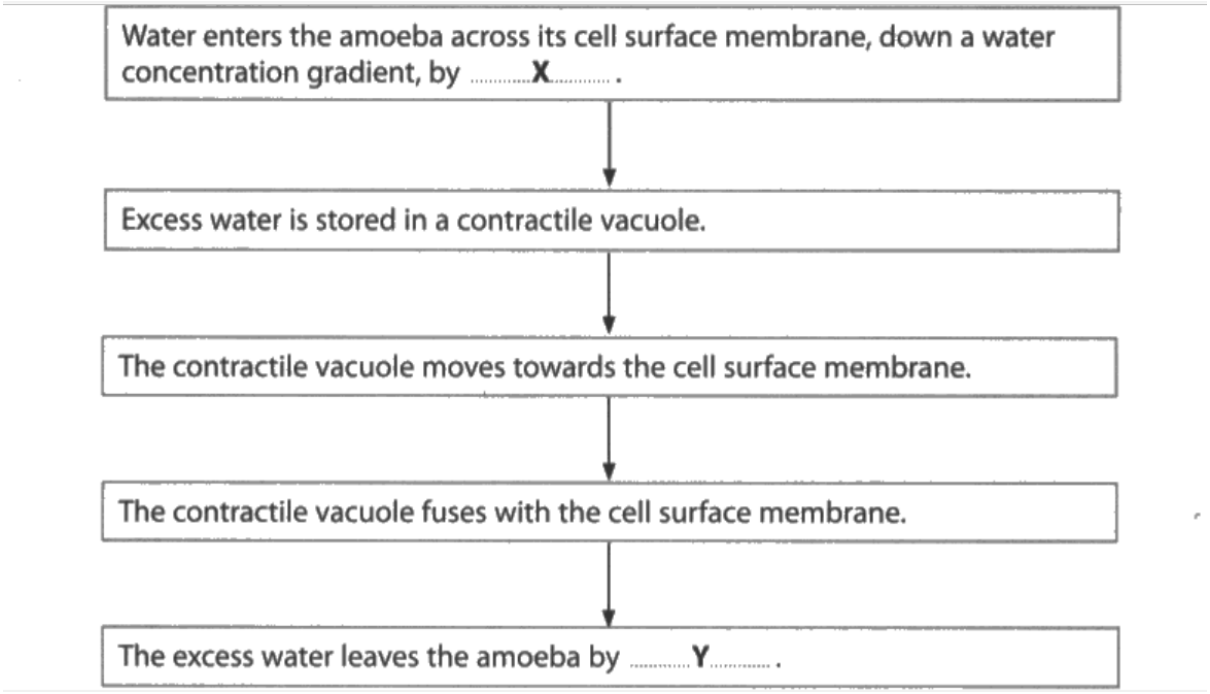
(b) Figure 2a shows a single-celled eukaryotic organism, *Amoeba proteus*, which inhabits fresh water.



Source: © Wim Van Egmond / Science Photo Library

Figure 2a

Figure 2b shows how water enters and leaves the amoeba.


Water enters the amoeba across its cell surface membrane, down a water concentration gradient, by ..... X .....
Excess water is stored in a contractile vacuole.
The contractile vacuole moves towards the cell surface membrane.
The contractile vacuole fuses with the cell surface membrane.
The excess water leaves the amoeba by ..... Y .....

Lead Examiner comment: *Most gave osmosis for X which is a correct response. Diffusion was also accepted for X as osmosis is the diffusion of water molecules. Facilitated diffusion was also accepted as water molecules pass through aquaporins in cell membranes. Many, however, did not give exocytosis for Y, but gave osmosis or diffusion again. However, some learners recognised that Y was an active process and gave active transport which was credited.*

This response gained 2 marks

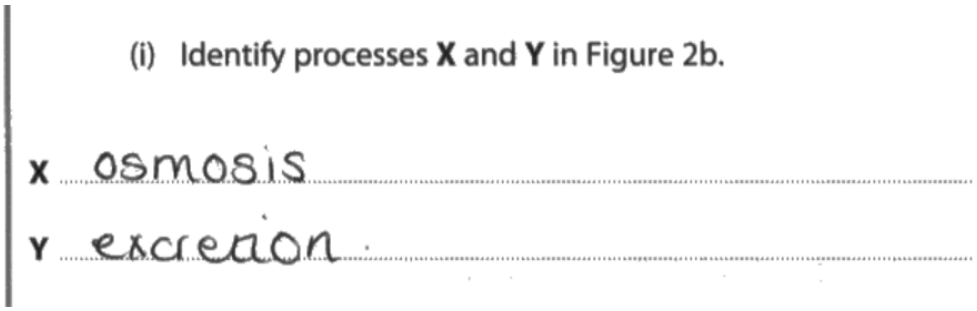
(i) Identify processes **X** and **Y** in Figure 2b. (2)

X osmosis

Y exocytosis

Lead Examiner comment: *X and Y are correctly identified.*

This response gained 1 mark



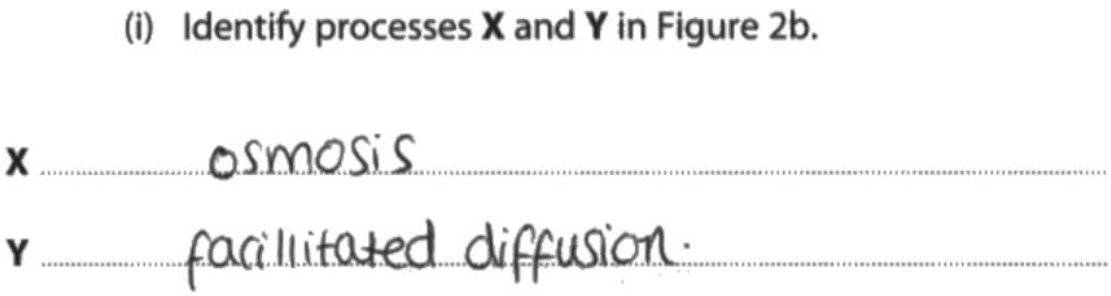
(i) Identify processes **X** and **Y** in Figure 2b.

X osmosis

Y excreaon.

Lead Examiner comment: *Osmosis is correct but the expulsion of water that has entered the cell and not produced in the cell is not an example of excretion.*

This response also gained 1 mark



(i) Identify processes **X** and **Y** in Figure 2b.

X osmosis

Y facilitated diffusion.

Lead Examiner comment: *Facilitated diffusion is not a correct response for Y.*

Q2(b)(ii) (1 mark)

Learners were asked which word describes the process of mainatinaing the water requirments of amoeba. The options were excretion, exhalation, hypertension and osmoregulation. Nearly all learners gave the correct answer of osmoregulation and were therfore applying their knowledge of this concept, learnt in the context of the kidney, to a novel context.

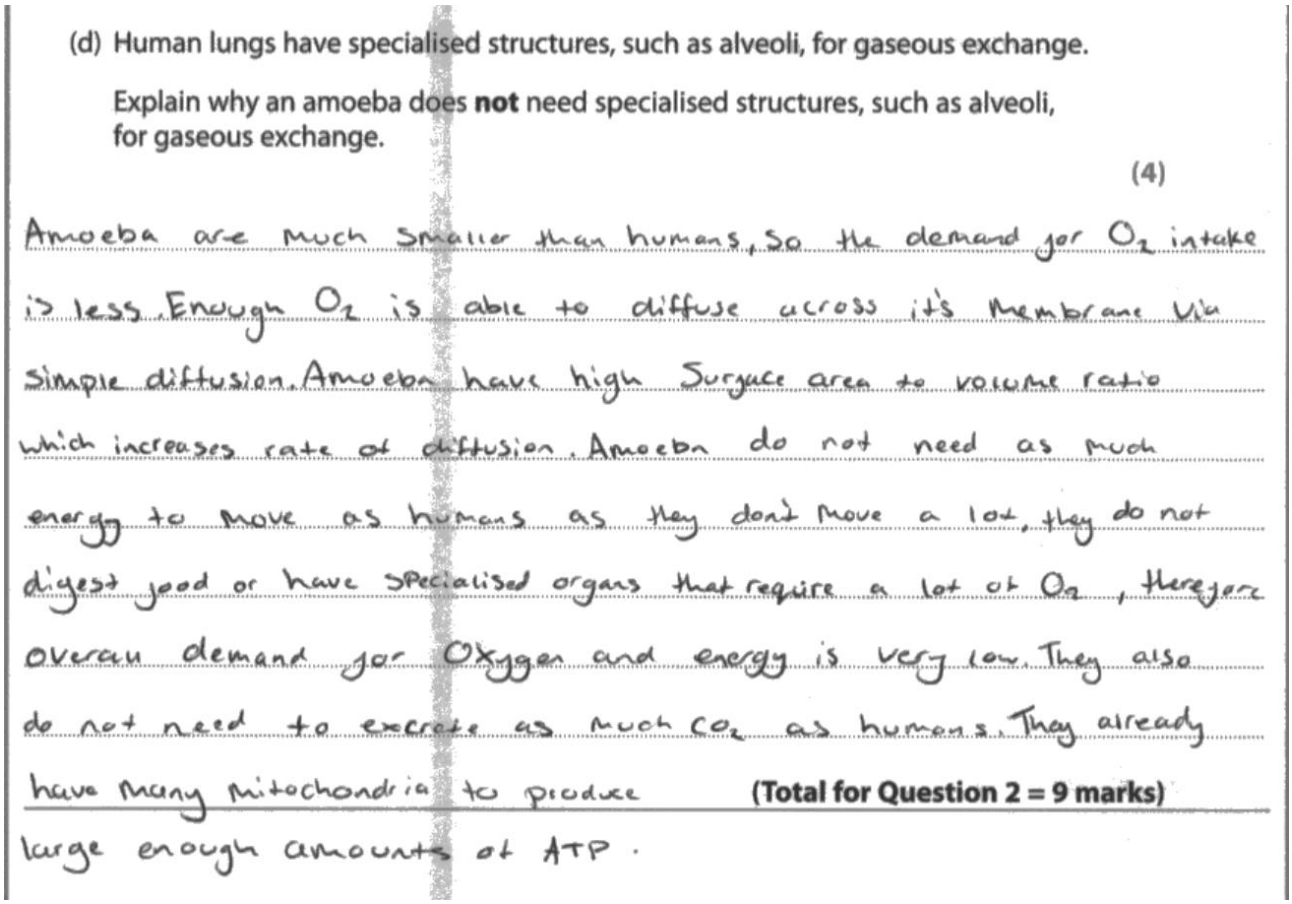
Q2(c) (1 mark)

In this multiple choice question learners were reminded that mitochondria produce ATP and were asked why the amoeba needs many mitochondria. Many correclty used the information thay had been given at the beginning of the question and deduced correctly that it was for the movement of the contractile vacuole but a significant few opted for ' for anaerobic respiration', 'for entry of water into the cell' or 'for diffusion of oxygen into the cell'. These responses were disappointing as learners are expected to know that anaerobic respiration does not involve mitochondria, and that osmosis and diffusion are both passive means of transport across cell membranes.

Q2(d) (4 marks)

In this question learners were asked to explain why an amoeba does not need specialised structures, such as alveoli found in human lungs, for gaseous exchange. It was hoped that learners would apply what they know about small organisms giving a larger surface area: volume ratio which meant that it was a short distance for the cell surface membrane to the organelles, partculalry mitochondria, inside the cell and that diffsuion alone through the cell surface membrane would deliver enough oxygen to these mitochondria for aerobic respiration, and also remove the carbon dioxide produced. Most realised that the fact that ameoba was small/unicelluar was important and that it had a relatively large suface for diffusion. Some learners also mentioned a short diffusion pathway or that the amoeba is surorunded by water which contains dissolved oxygen that can easily diffuse through its membrane. However there were some learners who thought that the amoeba was not living and so did not need gaseous exchange or that it only respired anaerobically (despite the information about its mitochondria).

This response gained 4 marks



(d) Human lungs have specialised structures, such as alveoli, for gaseous exchange.

Explain why an amoeba does **not** need specialised structures, such as alveoli, for gaseous exchange.

(4)

Amoeba are much smaller than humans, so the demand for O_2 intake is less. Enough O_2 is able to diffuse across it's membrane via simple diffusion. Amoeba have high surface area to volume ratio which increases rate of diffusion. Amoeba do not need as much energy to move as humans as they don't move a lot, they do not digest food or have specialised organs that require a lot of O_2, therefore overall demand for Oxygen and energy is very low. They also do not need to excrete as much CO_2 as humans. They already have many mitochondria to produce large enough amounts of ATP.

(Total for Question 2 = 9 marks)

Lead Examiner comment: *The learner has correctly identified that amoebae are small and have a large SA/V ratio and that oxygen can diffuse through its surface membrane, enough to meet its needs, as it has a lower energy requirement than humans. This is a very good answer indicating a high level of understanding.*

This response gained 3 marks

(d) Human lungs have specialised structures, such as alveoli, for gaseous exchange.

Explain why an amoeba does **not** need specialised structures, such as alveoli, for gaseous exchange.

(4)

They have thin membranes so have a really short diffusion pathway mainly diffusion easy in an amoeba. They do not require as much oxygen as us so live/respire therefore less oxygen is needed meaning specialised structures aren't needed.

Lead Examiner comment: *The learner has referred to thin membranes, which was accepted as an alterntive for large surface, giving a short diffusion distance. However, they have not linked the reference to lower oxygen demand to the concept of a lower demand for energy by this simple unicellular organism.*

This response gained 2 marks

(d) Human lungs have specialised structures, such as alveoli, for gaseous exchange.

Explain why an amoeba does **not** need specialised structures, such as alveoli, for gaseous exchange.

(4)

Because it is a single celled organism, meaning its ~~strucb~~ structure is simpler than a human.

Another reason is due to less ATP and O_2 ~~is~~ ~~re~~ being required for the amoeba to function, compared to a human.

Lead Examiner comment: *The learner has said the amoeba is unicellular and has a lower demand for energy.*

This response gained 0 marks

(4)

Aveoli is used for gas exchange in human body so respiration can occur. This eukaryotic cell doesn't require this due to the fact that eukaryotic cells can survive with ~~less~~ our oxygen.

Lead Examiner comment: *There is nothing creditworthy in this response.*

Question 3

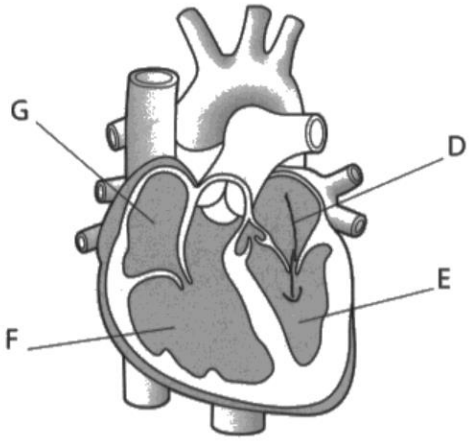
This question focused on the heart.

Q3(a) (1 mark)

Learners were asked to draw an arrow on a diagran of a section through a heart to show the path of blood through the left side.
Some drew arrows on both sides, presenting a list to the examiner and losing the mark. Some drew arrows only on the right side of the heart.
Some learners showed blood going from left side to right side or flowing through the septum lengthwise.

This response gained 1 mark

3 Figure 3 shows the structure of a human heart and associated blood vessels, seen from the front.



Source: adapted from © Paul Wootton / Science Photo Library

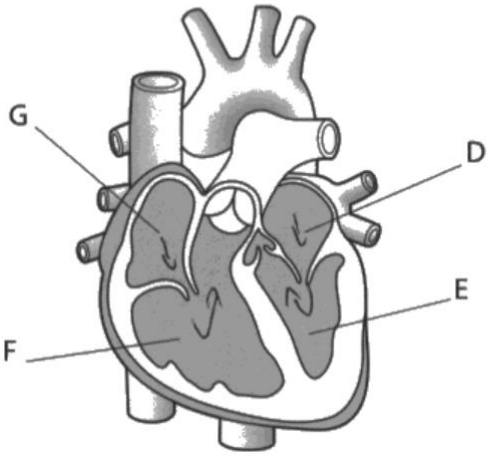
Figure 3

(a) Draw an arrow on Figure 3 to show the direction of blood flow through the left side of the heart.

Lead Examiner comment: *Responses that showed the blood passing from left atrium into left ventricle and then out through the aorta also gained the mark.*

This response gained 0 marks

3 Figure 3 shows the structure of a human heart and associated blood vessels, seen from the front.



Source: adapted from © Paul Wootton / Science Photo Library

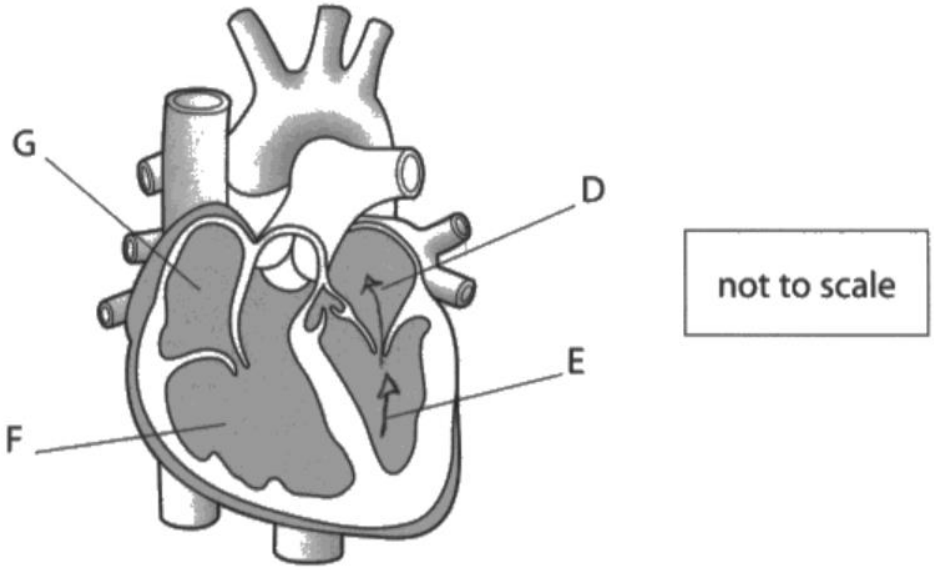
Figure 3

(a) Draw an arrow on Figure 3 to show the direction of blood flow through the left side of the heart.

(1)

Lead Examiner comment: *The incorrect response here negates the correct response as it contradicts it.*

This response gained 0 marks



Source: adapted from © Paul Wootton / Science Photo Library

Lead Examiner comment: *The blood is shown flowing in the wrong direction.*

Q3(b) (3 marks)

This question tested knowledge and understanding of the relative thicknesses of the walls of the ventricles and atria and of the right and left ventricles.
The letters D E F and G relate to the chambers as shown on the diagram above.

This response gained 3 marks

(b) A scientist measured the thickness of the muscle wall of each of the four heart chambers, D, E, F and G, shown in Figure 3.

The measurements were:

8 mm	16 mm	3 mm	3 mm

Complete Table 2 for chambers D, E and F.

Chamber G has been completed for you.

(3)

chamber	thickness of muscle wall (mm)
D	3
E	16
F	8
G	3

Table 2

Lead Examiner comment: *The learner has deduced that the thickness of chamber D - the left atrium wall, is the thinnest of the options and the same as that of chamber G; and that the wall thickness of chamber E, the left ventricle, is much greater than that of the wall of the right ventricle.*

Q3 (c) (3 marks)

This question asked about the significance of the time delay at the AV node that delays the impulses reaching the specially adapted muscle fibres, the bundle branches or purkyne fibres. There was a diagram to help cue the learners. Most learners understood that if this did not happen the rhythm of the heart would be disrupted and that the atria and ventricles should not be contracting at the same time. More detailed responses detailed that it allows the atria to fully empty their blood or to finish contracting and to allow the ventricles to fill and for the SA valves to close preventing backflow, before the ventricles begin to contract.

This response gained 3 marks

(c) Figure 4 shows the positions of the nodes that regulate the rhythm of the heartbeat.

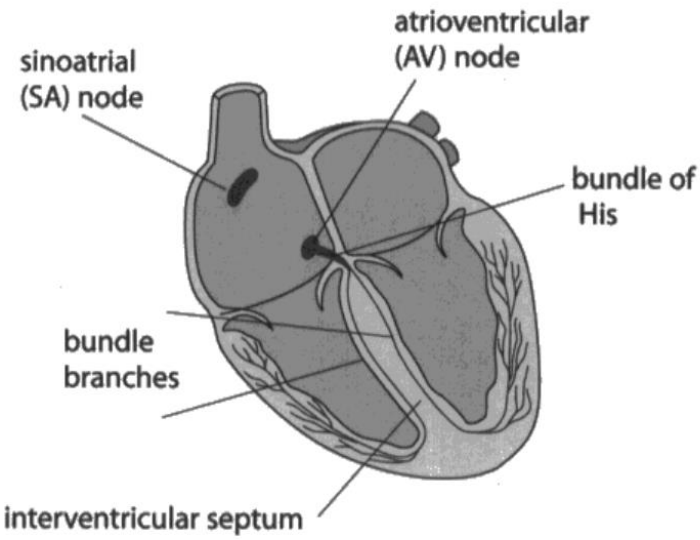


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Figure 4

The impulse first spreads from the SA node to the AV node.

Then the impulse travels through the bundle of His and the bundle branches.

There is a time delay at the AV node as the impulse spreads.

Explain why this time delay is important

(3)

The time delay at the bundle of his is very important as the atrial contraction, blood Pumping is required before the ventricular contractions as. The atriums and ventricles can't be pumping at the same time Weeds time for bicuspid and tricuspid valves to close

(Total for Question 3 = 7 marks)

Lead Examiner comment: *The three marks are for the ides of atrial contractions needing to finish before the ventricles contract and for the valves to close.*

This response gained 2 marks

(3)

There is a 0.3s time delay when the electrical impulse spreads from SA node to AV node.

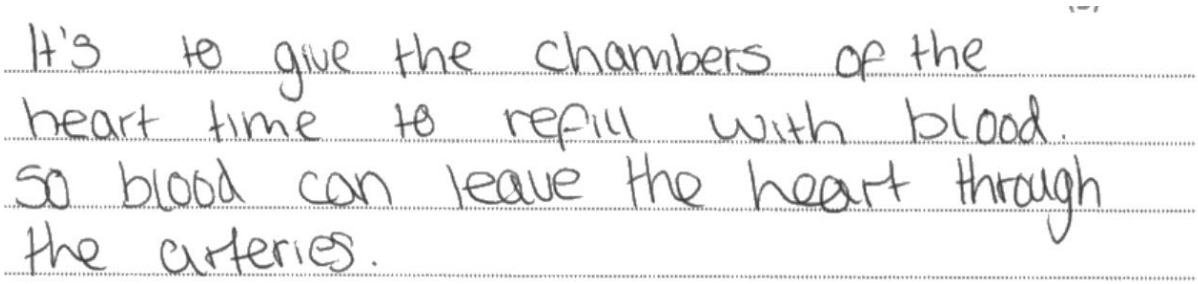
The time delay allows the blood from the atria to completely flow to the ventricles by contraction.

If the atria and ventricles contracts at the same time, blood is not able to flow as the pressure of both atria and ventricles are the same.

(Total for Question 3 = 7 marks)

Lead Examiner comment: *This response also states that the atria must completely empty before the ventricles contract.*

This response gained 0 marks



Lead Examiner comment: *This is too vague and does not offer an adequate explanation as it does not specify which chambers are filling or emptying.*

Question 4

This question is about spirometer traces.

Q4(a) (1 mark)

The learners were shown a diagram showing a part of a spirometer trace and asked by multiple choice, which letter on the diagram showed the tidal volume. The distractors showed, by letters not actual names, the inspiratory reserve volume, the vital capacity and the residual volume. Most learners gave the correct response but there were some who chose IRV, some chose vital capacity and some chose residual volume. This indicates that not all learners understand these terms or can equate these volumes to what is seen on a spirometer trace.

Q4(b)(i) (4 marks)

Learners were given a diagram of part of a spirometer trace and asked to calculate the oxygen consumption of a student, during a specific time period, while connected to the spirometer and cycling vigorously. They were given a formula and asked to calculate this rate of oxygen consumption in mL per kg body mass per second.

Most leaners knew that the slope of the graph indicated the volume of oxygen used and read the graph correctly to find the volume used during the stated time period. However, some learners did not correctly convert litres to millilitres and instead of multiplying by 1000 some multiplied by 100 and some divided by 1000. Some read the graph incorrectly in the first place. Some used the incorrect time period and did not divide by 60 as told to do.

This response gained 4 marks

(i) Calculate the student's rate of oxygen consumption from 60 to 120 seconds.

(4)

Show your working.

2L = 2000 ÷ 70 ÷ 60 = 0·476190

rate of oxygen consumption = 0·476190 ml kg^{-1} s^{-1}

Lead Examiner comment: *The correct reading was carried out, this value then correctly converted to mL and then the appropriate divisions carried out, giving the correct answer.*

This response gained 3 marks

(i) Calculate the student's rate of oxygen consumption from 60 to 120 seconds.

(4)

Show your working.

body mass = 70kg
s.v = 170ml
time = 60s

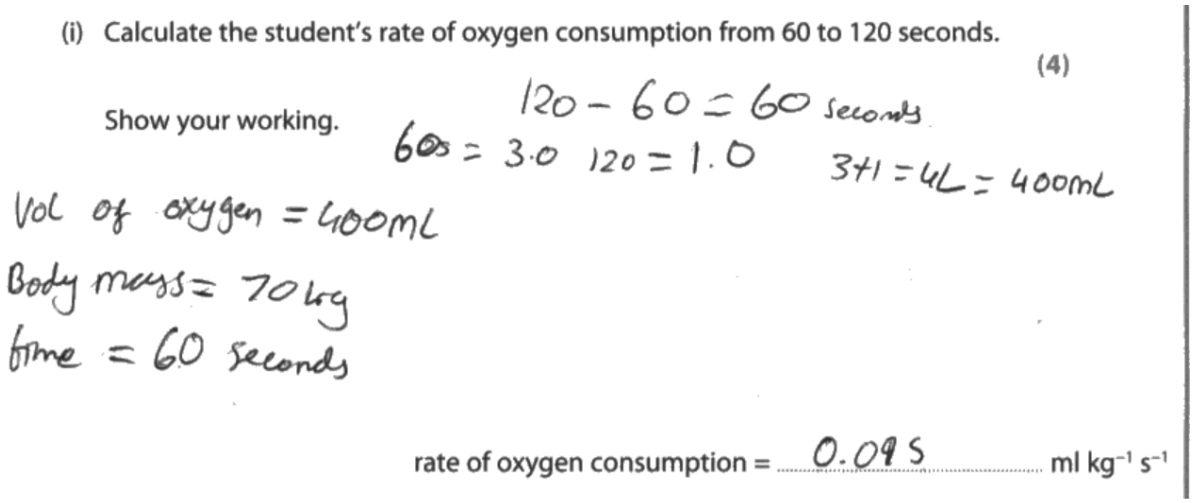
3.6
-1.9
200

200 ÷ 70 ÷ 60

rate of oxygen consumption = 0.05 ml kg^{-1} s^{-1}

Lead Examiner comment: *The learner has used 2L but incorrectly converted it to 200 mL. They have then carried out the next steps properly so gain 3 marks as error carried forward. The response is a factor of 10 out.*

This response gained 2 marks



(i) Calculate the student's rate of oxygen consumption from 60 to 120 seconds. (4)

Show your working.

120 − 60 = 60 seconds

60s = 3.0 120 = 1.0 3+1 = 4L = 400mL

Vol of oxygen = 400mL

Body mass = 70kg

time = 60 seconds

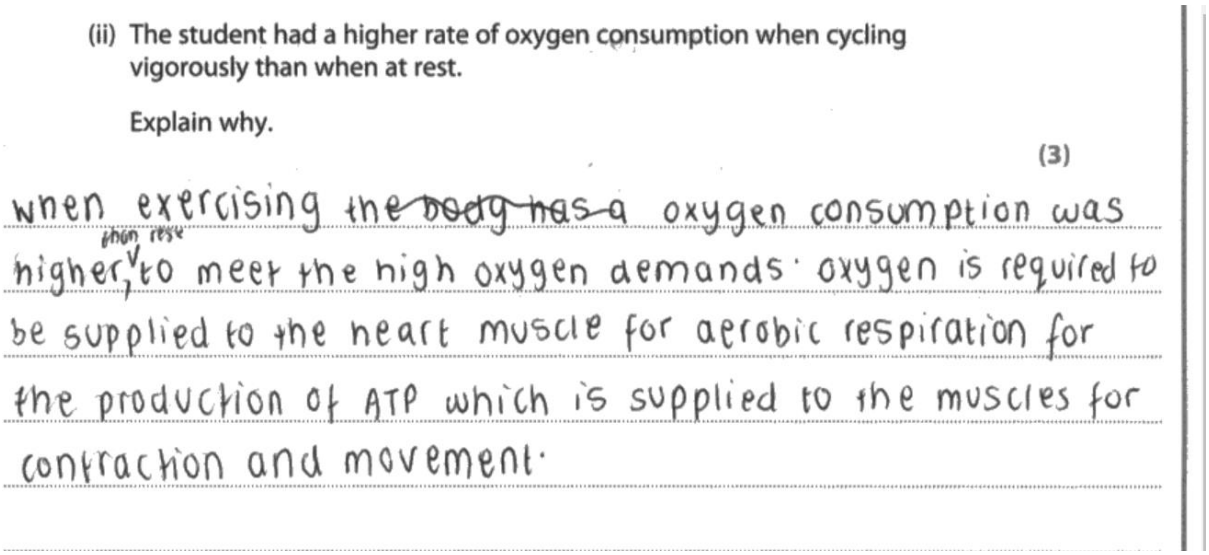
rate of oxygen consumption = 0.095 ml kg^{-1} s^{-1}

Lead Examiner comment: *The learner has taken an incorrect reading from the graph and has incorrectly converted that value in L to mL and then carried out the divisions so gains 2 marks as error carried forward.*

Q4(b)(ii) (3 marks)

Learners were asked to explain why the students' rate of oxygen consumption was higher when he was cycling compared to when at rest. Most learners appreciated that the muscles would be contracting more and so need more ATP and therefore need more (aerobic) respiration to make the extra ATP and /or to prevent the build up of lactic acid.

This response gained 3 marks



(ii) The student had a higher rate of oxygen consumption when cycling vigorously than when at rest.

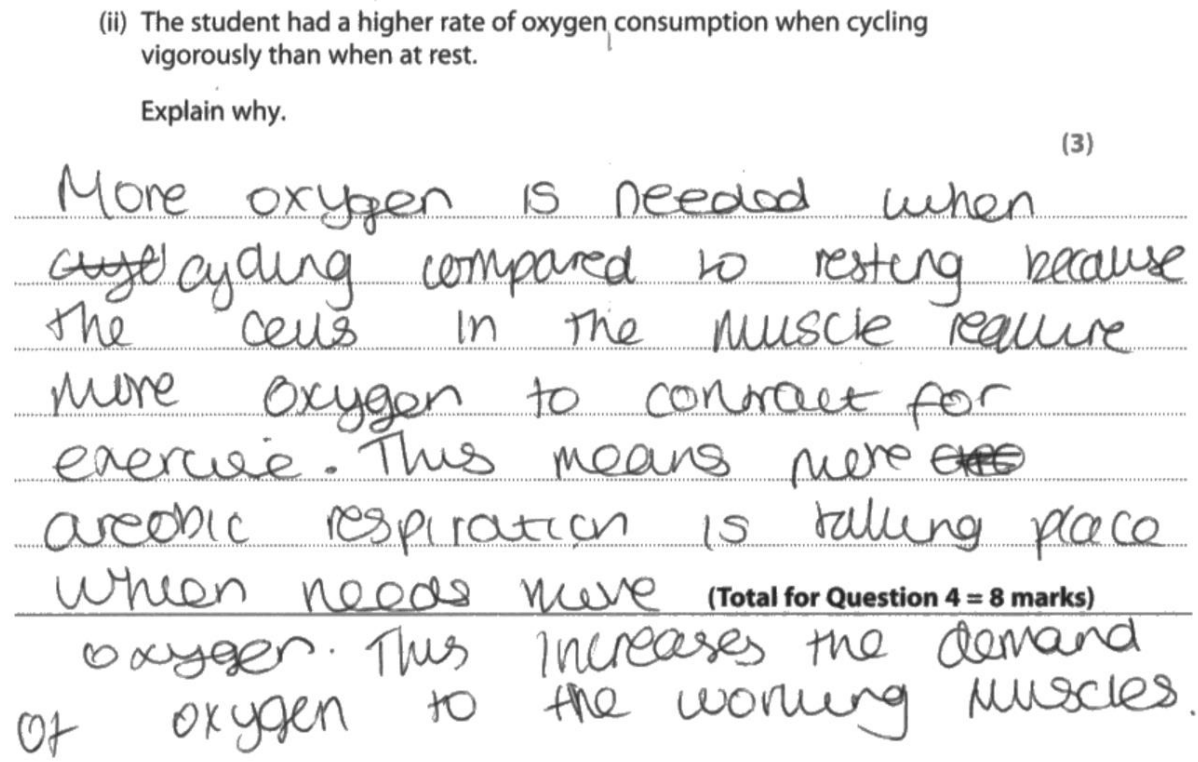
Explain why.

(3)

when exercising the ~~body has a~~ oxygen consumption was higher (than rest), to meet the high oxygen demands. oxygen is required to be supplied to the heart muscle for aerobic respiration for the production of ATP which is supplied to the muscles for contraction and movement.

Lead Examiner comment: *This response implies that there is more respiration as it is in the context of more contraction of muscles.*

This response gained 2 marks



(ii) The student had a higher rate of oxygen consumption when cycling vigorously than when at rest.

Explain why.

(3)

More oxygen is needed when ~~cycl~~ cycling compared to resting because the cells in the muscle require more oxygen to contract for exercise. This means more ~~aer~~ aerobic respiration is taking place when needs more oxygen. This increases the demand of oxygen to the working muscles.

(Total for Question 4 = 8 marks)

Lead Examiner comment: *This response also indicates an increased level of muscle contraction and clearly states that more aerobic respiration is taking place.*

One common slip made by many learners was to say that more ATP is needed for respiration rather than the extra ATP is made during respiration.

Question 5

This question asked learners compare the structures of arteries, veins and capillaries and to refer to similarities as well as differences.

Good (Level 3) responses demonstrated comprehensive knowledge and understanding by selecting and applying relevant knowledge of scientific facts and use of correct terminology. The response also showed a well-developed structure with clear and coherent communication. Many of the learners showed comprehensive knowledge and understanding and gave some similarities – all have a lumen and an endothelium and are round and discussed differences by referring to the thickness of the walls, lumen sizes, the layers of the walls, relative amounts of muscle and elastin and the presence or absence of valves. The responses did not have to be in prose; tables, annotated diagrams and bullet points were acceptable.
Some excellent responses referred to folded linings of the arteries to allow them to dilate as blood enters from the heart. Good responses also referred to dilation and recoil of the arteries as linked to the amounts of muscle and elastin in the walls.

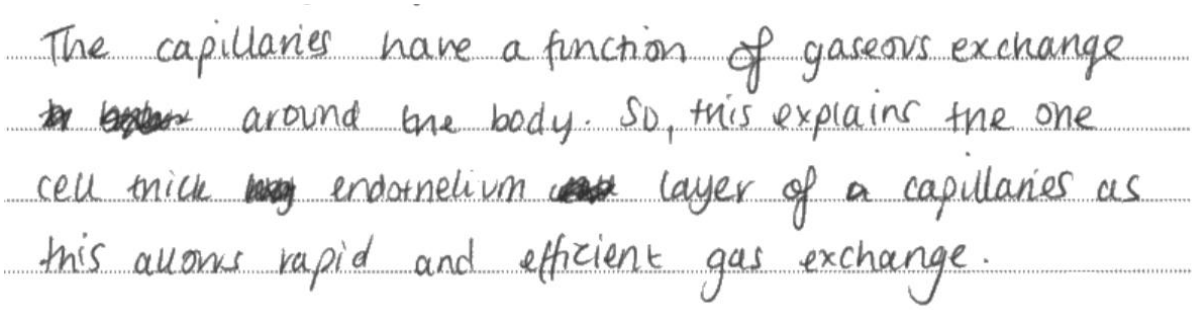
Level 2 responses showed good knowledge and understanding by selecting some relevant scientific facts and presenting them in a mostly clear, logical and coherent way.
A large group of learners achieved level 2 for this question. Some of them, however, mistakenly think that artery walls, due to their muscle content, contract to pump blood along, as opposed to dilating and recoiling as blood surges through them.

Level 1 responses showed a few scientific facts possibly with many misconceptions and confused ideas.

Weaker responses focussed on functions of the three types of blood vessels rather than their structures. Many of the learners also confused arteries and veins as to which have the thickest walls, and which have valves. Some learners think capillaries are much larger than arteries. Some also think that capillaries carry blood at high pressure or that veins carry blood at high pressure.

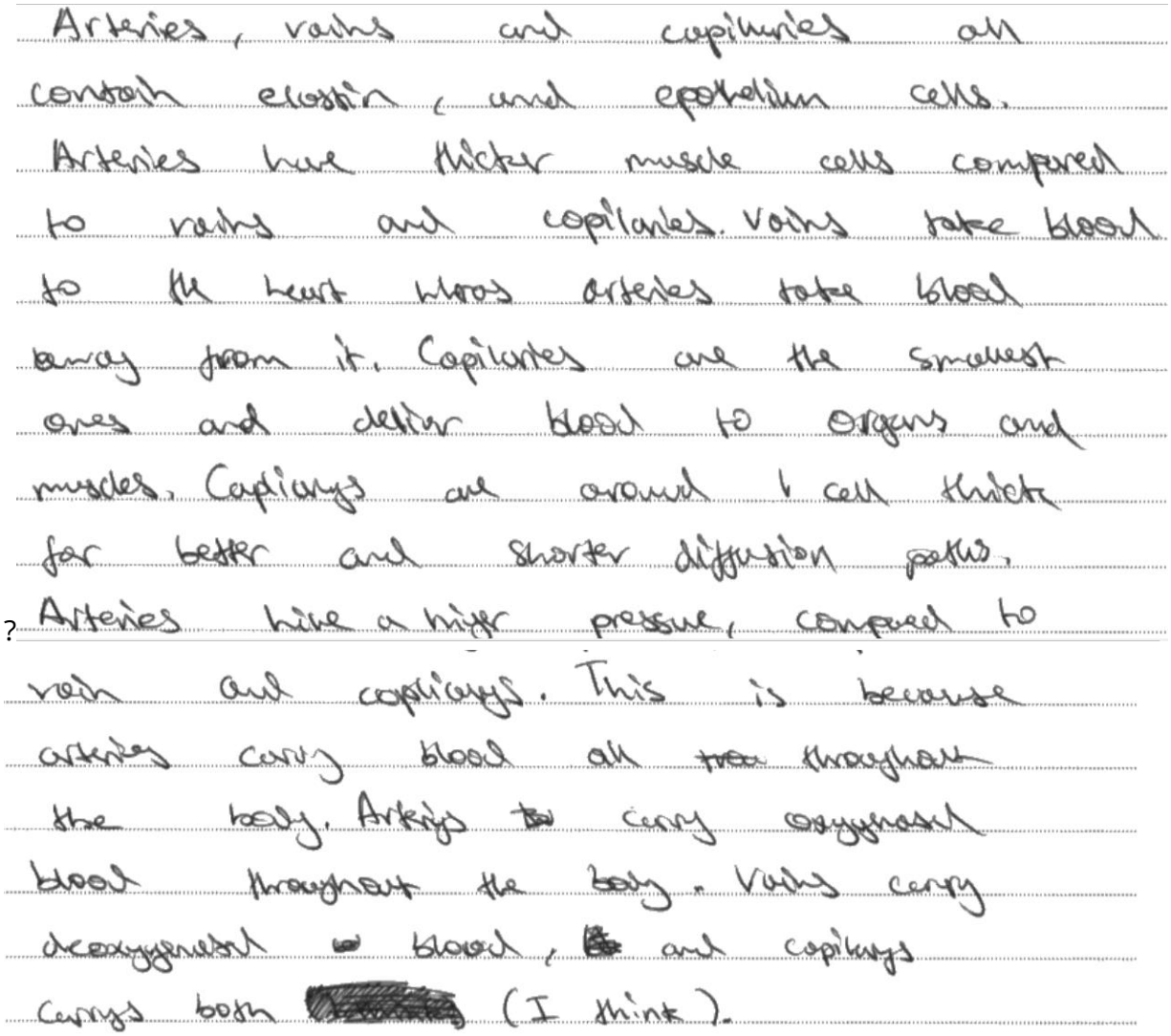
The following response is worthy of top Level 3 with 6 marks

The veins and capillaries are somewhat similar as they are both smaller blood vessels than the arteries. However, they do attain a many differences such as that vein has a very large lumen and capillaries are quite narrow and have a smaller lumen than veins. Regarding, lumen, arteries have small lumen compared to veins. Arteries consists of thick muscular walls as well as elastic fibres which help both for maintaining high pressure of blood (muscular walls) and the elastic fibres help with the dilation and constriction of arteries depending on the condition of the environment. On the other hand, veins consists of thin muscular walls and elastic fibres as they carry blood to the heart under low pressure and the once again the elastic fibres help with constriction and dilation, adjusting the amount of blood being carried. The arteries and veins also have layer of endothelium tissue under the layer of smooth muscle.


The capillaries have a function of gaseous exchange around the body. SO, this explains the one cell thick endothelium layer of a capillaries as this allows rapid and efficient gas exchange.

Lead Examiner comment: *The learner has referred to size, lumens, smooth muscle, elastin and endothelium. They have also given some similarities and there is nothing incorrect here and correct terminology is used throughout.*

This response is worthy of Level 2 with 3 marks


Arteries, veins and capillaries all contain elastin, and epithelium cells. Arteries have thicker muscle cells compared to veins and capilaries. Veins take blood to the heart whereas arteries take blood away from it. Capilaries are the smallest ones and deliver blood to organs and muscles. Capilarys are around 1 cell thick for better and shorter diffusion paths. Arteries have a higer pressure, compared to vein and capilarys. This is because arteries carry blood all throughout the body. Arteries carry oxygenated blood throughout the body. Veins carry deoxygenated blood, and capilarys carrys both (I think).

Lead Examiner comment: *The terminology is not as clear – the learner refers to thicker muscle cells and epithelium cells rather than endothelium. However, as endothelium is merely internal lining (epithelial) tissue this is not so bad. Many learners say that capillaries are one cell thick and we know what they mean – a reference to their walls.*

The following response is worthy of top Level 2 with 4 marks

5 Compare the structures of arteries, veins and capillaries. **(6)**

Your answer should refer to both similarities and differences.

You may use annotated diagrams and/or a table to support your answer.

The capillaries are smaller than the veins and arteries in size. The ~~the~~ arteries are the biggest. The lumen of the arteries is more narrow than that of the capillaries and the veins.

The veins and capillaries are somewhat similar as they are both smaller ~~and~~ blood vessels than the arteries. However, they do attain a many differences such as that vein has a very large lumen ~~in~~ and capillaries are quite narrow and have a smaller lumen than veins. Regarding, lumen, arteries have small lumen compared to veins. ~~Arteries are thick, Arteries~~ Arteries ~~and veins~~ consists of thick muscular walls as well as elastic fibres which help both for maintaining high pressure of blood (muscular walls)

and the elastic fibres help with the dilation and constriction of arteries depending on the condition of the environment. On the other hand, veins consists of thin muscular walls and elastic fibres as they carry blood to the heart under low pressure and the once again the elastic fibres help with constriction and dilation, adjusting the amount of blood being carried. The arteries and veins also have layer of endothelium tissue under the layer of smooth muscle.

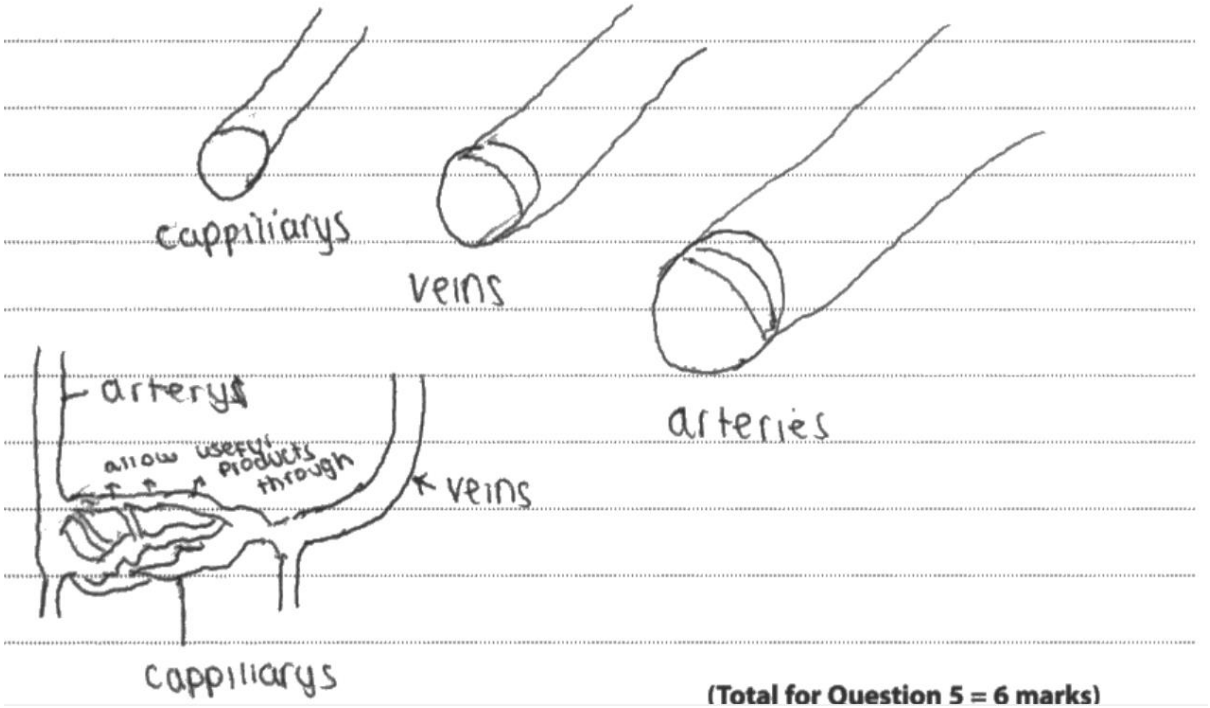
The capillaries have a function of gaseous exchange around the body. So, this explains the one cell thick endothelium layer of a capillaries as this allows rapid and efficient gas exchange.

Lead Examiner comment: *There are some inaccuracies in here, but it is quite a well-constructed answer.*

This response is worthy of Level 1, 2 marks

arteries are much bigger than veins and capillaries as it carries more blood. cappiliaries are much smaller than veins and arteries. the pulmonary arteries job is to take deoxygenated blood to the lungs from the heart and to do this they must be larger as well as having thick cell walls to withstand the pressure of blood being pumped through. The veins are smaller but are spiit into many smaller veins for example the pulmonary veins are spiit into four different veins and there role is to send oxygenated blood to the heart. the Cappiliaries are so have a small network where there are a bunch of them being very small connecting to the arterie and veins. the cappillarys have thin cell walls which allow useful products from the blood to pass through into the body. The veins and arteries are similar in the fact that they both take oxygenated blood around the body. They both also have many

different roles and there are many different types of them for example pulmonary arteries and veins.



(Total for Question 5 = 6 marks)

Lead Examiner comment: *Much of this response is about function rather than structure and is rather vague.*

Summary

Based on their performance on this paper, learners should:

- Always read the question carefully, understand which command word is being used and tailor their response accordingly.
- Read the information/scenario given in the stem of the question as it will help and guide them towards the appropriate response.
- Make sure they refer back to any data, such as photographs, diagrams, tables or graphs, to help them answer the question.
- Not repeat the question as part of the response.
- Use appropriate technical terminology throughout responses. For example, when talking about the movement of oxygen across cell surface membranes, refer to diffusion.
- Tailor their response based on the command word in the question; identify does not require any expansion of a point but explain will require a reason for how or why something happens. Describe does not need a reason as to why or how something happens but they need to describe what is happening.
- Use the number of marks gained and the space available as a guide to the depth of response required. If the command word is 'identify' or 'name' then usually only a word is needed. Do not waste time writing more; that time can be better used when answering the longer questions.
- Be clear about terminology used in the specification as these words will be expected in responses, e.g. osmosis, diffusion, exocytosis, endothelium, metabolism, aerobic respiration.
- Be clear about the names and functions of all structures and chemicals listed in the specifications as questions will be asked about them, for example the role of the nephron in selective reabsorption or the names of the layers of the walls of blood vessels.

- Use the question scenario to demonstrate your ability to apply your knowledge to a new situation.
- Try to spell words correctly. We usually accept phonetic spellings but sometimes a mis-spelt word becomes another word and then it cannot be accepted, for example deoxygenated and oxygenated or anaerobic and aerobic.
- Make sure you understand how to read values from a graph and how to convert litres to milliltres.
- Try to refer to ATP rather than energy when appropriate. Remember that ATP is produced during respiration.
- Some learners run out of time for the last question. They can answer that question first, before they get too tired, and then answer the shorter questions, but, if they do this, they should not spend too long on the 6 mark question and deny themselves enough time to tackle all the other questions.

Individual Questions

Chemistry

Q1(a)

This multiple-choice question tested whether learners could identify the method of extraction of aluminium from aluminium oxide.
About 81% of learners did identify electrolysis as being the correct method. Other options were selected in equal proportion, and are key processes covered in the content associated with this unit.

Q1(b)(i)

Here learners were supplied with an ionic equation to balance.
Just over a third of learners were able to balance the equation correctly.

2 marks

Approximately a quarter of learners were able to offer one side of the equation correctly balanced. This was generally the right-hand side as the left-hand side clearly showed two aluminium atoms in the formula.

1 mark

A disappointingly high proportion of learners, some 40%, were unable to balance either side of the equation, despite it already being partly balanced already. Whilst incorrect numbers were often observed as being used, it was also common to see a variety of symbols that were not numbers. It was sometimes the case that learners attempted to "restore" the equation to a full chemical equation by reintroducing the chloride spectator ions, but there were also some odd inclusions such as oxygen or other elements.

0 marks

Centres must ensure that this basic of chemical skills is practiced thoroughly and frequently throughout the teaching of the subject. Centres must also include ionic and half equations to ensure that learners are fully prepared.

Q1(b)(ii)

This question also offered learners another opportunity to complete information, but this time in order to demonstrate their understanding of the acid-base behaviour of aluminium oxide as an amphoteric substance.

Just under 50% of learners were able to score 1 of the 2 available marks, and this was almost always for it acting as an acid. Many, but fewer, learners were able to score the full two marks, suggesting an unfamiliarity with the hydroxide ion. A large number of answers often referred to the chloride ion instead. This response presumably took its cue from the earlier reference to hydrochloric acid and reasoning that if the hydrogen ion had reacted then this was what was left.

When aluminium oxide is reacted with hydrogen ions, the aluminium oxide dissolves because it acts as a base.

However, when aluminium oxide reacts with .....A..... ions, the aluminium oxide dissolves because it acts as an .....B..... .

This shows that aluminium oxide is amphoteric.

Paragraph 1

A ..... chloride .....

B ..... Acid .....

1 mark

A ..... hydroxide .....

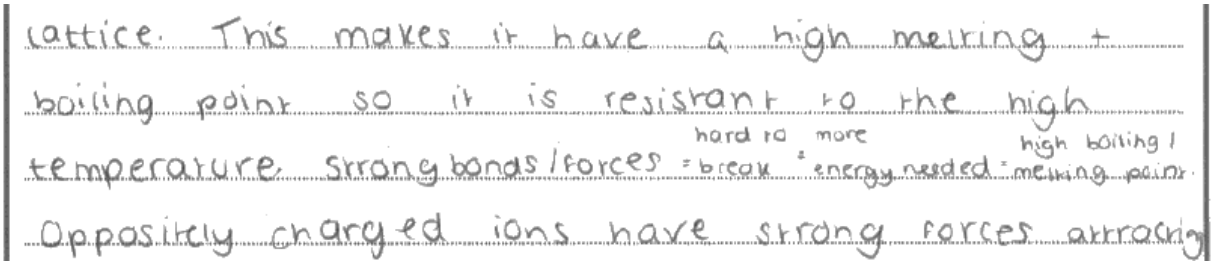
B ..... [illegible] acid .....

2 marks

Again, a disappointingly high proportion of learners, some 40%, did not recognise that they were providing a description of amphoteric behaviour, even though this was confirmed within Paragraph 1 and despite the second sentence mirroring the wording of the first sentence and could be worked out.

Q1(c)

This question asked learners to explain why aluminium oxide was resistant to high temperatures and required reasoning based upon the structure and bonding of the compound. Although only the very best learners would be expected to score full marks, all learners would be expected to be able to identify some relevant property or feature. However, just under half of the cohort scored any marks at all on this question.


lattice. This makes it have a high melting +
boiling point so it is resistant to the high
temperature. strong bonds/forces = hard to break = more energy needed = high boiling / melting point.
Oppositely charged ions have strong forces attracting

Lead Examiner comment: *4 marks – this extract of a response is disorganised but shows creditworthy aspects – aluminium oxide has a high melting point, a lattice, oppositely charged ions, strong forces of attraction, and that energy is needed.*

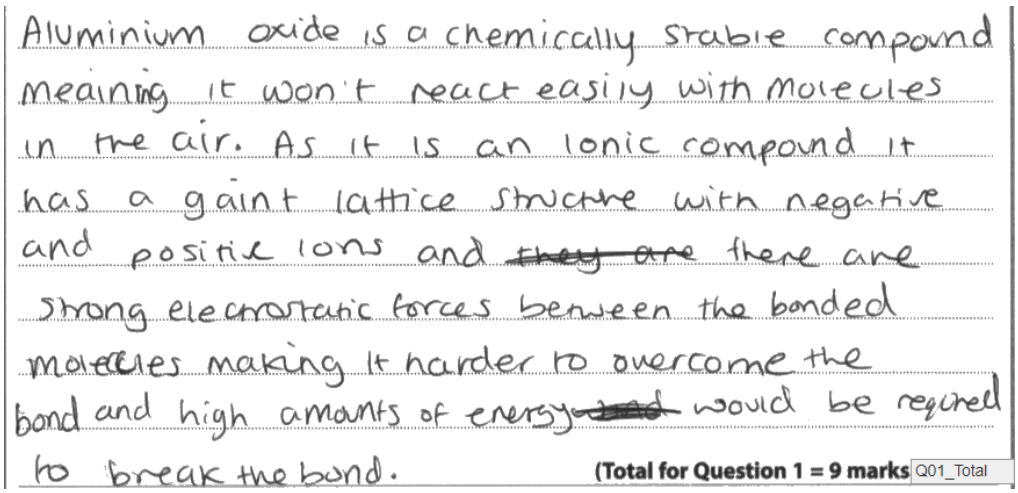
Relatively few learners were able to identify that a resistance to high temperature must mean that aluminium oxide has a high melting point. Whilst this could be inferred from the question context, it is clearly not a physical property that learners associate with aluminium oxide, despite it being a consideration in the extraction of aluminium by electrolysis, and one of the key characteristics of an ionic compound.

Despite the question identifying that aluminium oxide was ionic, many learners either did not see this as important information or chose to ignore this. It was very rare for any learner to offer what they knew and understood about ionic bonding and structure.

Responses often went in many different and irrelevant directions, often led by what was known about aluminium oxide or aluminium, including:

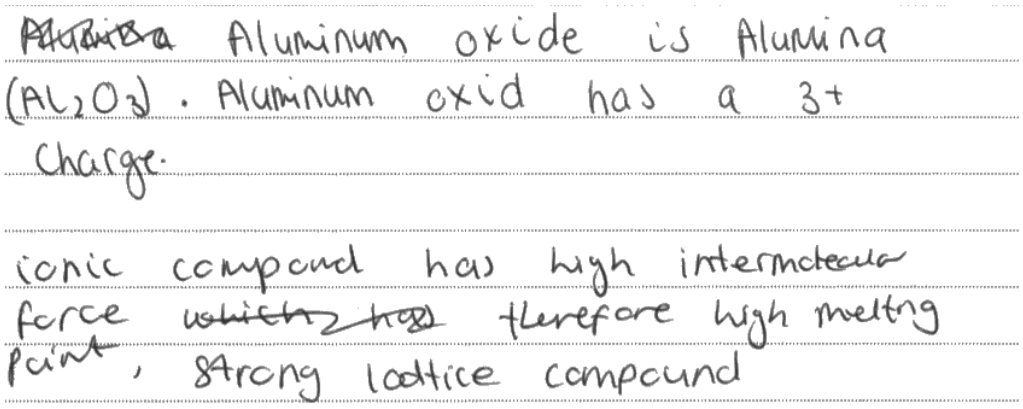
- electrolysis of aluminium oxide
- the extraction of aluminium oxide from its ore
- the amphoteric behaviour of aluminium oxide
- the properties and metallic structure of aluminium

Often where learners were in the correct general area by discussing energy requirements and the strength of bonding or forces of attraction, this was frequently undermined by references to nuclear attraction for electrons, intermolecular forces, atoms or molecules in place of ions. Clearly, these are core ideas in the subject at this level which learners are very familiar with and prepared upon. However, centres need to train learners to show greater awareness of the contexts set out in questions and to be more discerning about when it is appropriate to invoke the correct core principle.


Aluminium oxide is a chemically stable compound meaning it won't react easily with molecules in the air. As it is an ionic compound it has a gaint lattice structure with negative and positive ions and ~~they are~~ there are strong electrostatic forces between the bonded molecules making it harder to overcome the bond and high amounts of energy ~~need~~ would be required to break the bond.

(Total for Question 1 = 9 marks) Q01_Total

Lead Examiner comment: *3 marks – this extract of a response is logical and makes creditworthy points but undermines marks that could have been achieved by referring to molecules rather than ions.*


~~Aluminium~~ Aluminum oxide is Alumina (Al_2O_3). Aluminum oxid has a 3+ charge.

ionic compound has high intermolecular force ~~which has~~ therefore high melting point, strong lattice compound

Lead Examiner comment: *2 marks – this extract of a response is weak and refers to "intermolecular forces" rather than electrostatic forces of attraction between ions.*

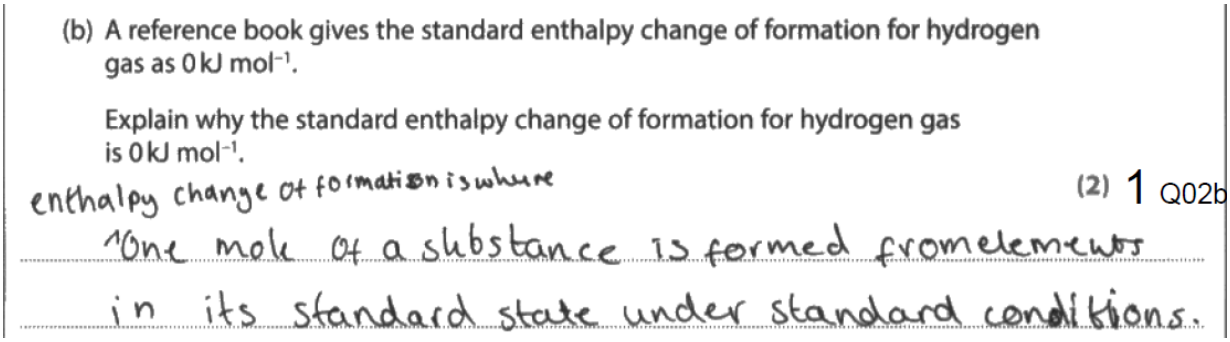
Q2(a)

Learners had to match the correct numerical value to standard temperature and pressure, from a selection of five numbers. The majority of learners successfully gained both marks. The most typical errors were to mix up the values for temperature and pressure, or selecting one of the other values for temperature. Learners may have mistakenly assumed that the standard temperature required was to be given in Celsius (ie 25 ^{o}C) or associated other constants with standard temperature (ie the boiling point of water as 100 ^{o}C or 373 K).

Q2(b)

This question primarily targeted more able learners, so was consequently answered poorly by most, with only about 30% of the cohort providing a response that could be rewarded with any marks. The question required a good understanding of the standard enthalpy change of formation and application to explain why this 0 kJ mol^{-1} for hydrogen.

Although this was not required, responses that gave a reasonable definition for the standard enthalpy change of formation were generally credited with a mark as this recognised that the answer had to be connected to it in some way. However, it was extremely rare that a learner was able to take their reasoning any further.



(b) A reference book gives the standard enthalpy change of formation for hydrogen gas as 0 kJ mol^{-1}.

Explain why the standard enthalpy change of formation for hydrogen gas is 0 kJ mol^{-1}.

enthalpy change of formation is where

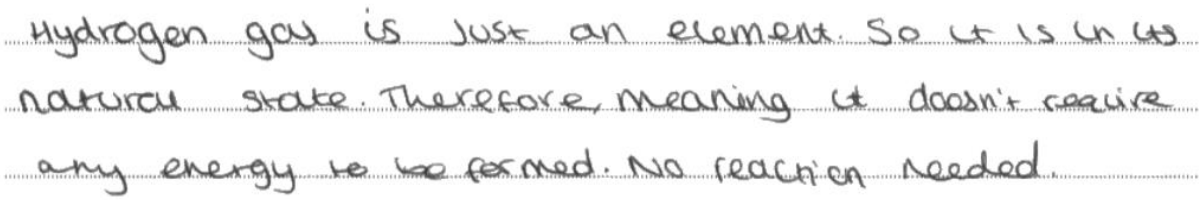
(2) 1 Q02b

One mole of a substance is formed from elements in its standard state under standard conditions.

Lead Examiner comment: *1 mark – the learner has provided a definition of standard enthalpy change of formation. Whilst relevant, it does not expand upon this or link it to the context.*

Many learners suggested that the reason for there being no value was because hydrogen was a gas, whilst others attached significance to hydrogen being the first in the periodic table, or having an atom that was the simplest, lightest, smallest, etc. Nevertheless, some learners were able to identify that hydrogen being an element was the reason, and so gained a mark, but they were then unable to link

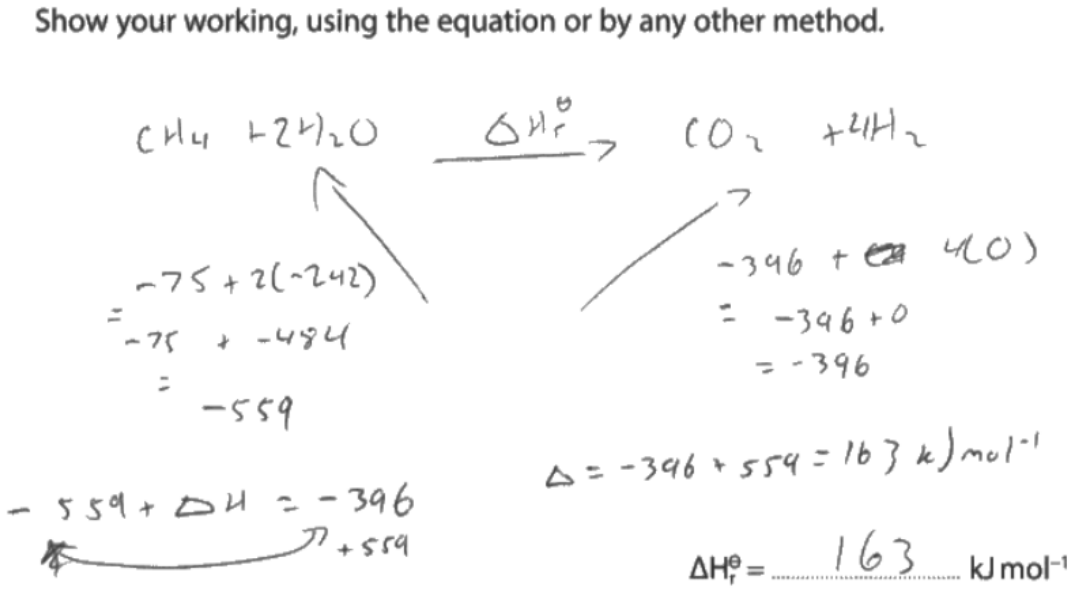
this to the idea that it could not be formed from elements and therefore there was no enthalpy change. Relatively few responses equated 0 kJ mol^{-1} with there being no chemical change or reaction involved.


Hydrogen gas is just an element. So it is in its
natural state. Therefore, meaning it doesn't require
any energy to be formed. No reaction needed.

Lead Examiner comment: *2 marks – although this response could be better expressed, it does contain creditworthy ideas. The learner has recognised that hydrogen is an element and in its "natural" state, rather than in its standard state. They have identified that it does not need any energy to be formed, and further emphasise that no reaction is needed.*

Q2(c)(i)

The calculation of the enthalpy change in the reaction of methane with steam often yielded good marks for learners. Full marks were frequently awarded and less than 10% achieved nothing at all on this question.


Show your working, using the equation or by any other method.
CH4 + 2H2O
ΔHr⊖
CO2 + 4H2
-75 + 2(-242)
= -75 + -484
= -559
-396 + 4(0)
= -396 + 0
= -396
- 559 + ΔH = -396
+559
Δ = -396 + 559 = 163 kJ mol-1
ΔHr⊖ = 163 kJ mol-1

Lead Examiner comment: *4 marks – the correct answer is shown on the answer line, with working to support it. The learner did not need to make clear the sign of the value but should be encouraged to do so for enthalpy change problems. Although an equation has been provided within the question, the learner has chosen to use a partially completed energy cycle – this is a perfectly valid means to arrive at the answer, and clearly shows the learner's working and key steps.*

3 marks tended to be the most common score and was achieved by about 42% of the cohort. The one error that most learners made was to omit the multiplication of the standard enthalpy change of formation for steam by 2. Otherwise, summation of enthalpy change of reactants, use of the provided equation and correct evaluation of a final answer were all done well. A smaller number of learners did actually arrive at the correct value of 163, but either decided to change the sign at some stage or intentionally substituted values in the wrong place in the equation.

(i) Calculate the value of $\Delta H_f^\ominus$ for the reaction of methane with steam, using the $\Delta H_f^\ominus$ data in Table 1.

Show your working, using the equation or by any other method.

(4) Q02c

Products Reactants

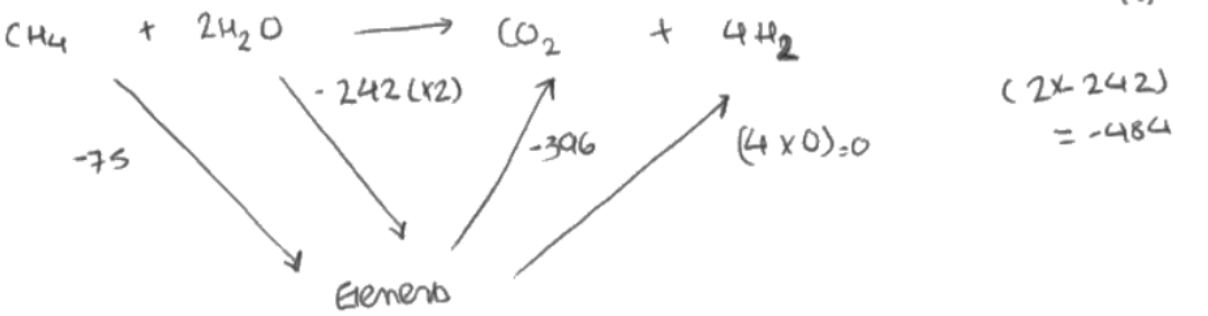
$(-396 + 0) - (-75 + -242) = \Delta H_f^\ominus$

$= -79$

Lead Examiner comment: *3 marks – the learner's working shows that they have used the provided equation and their working is clear. Whilst addition, substitution and evaluation marks have been gained, it can be seen that they have omitted to multiply the enthalpy change of formation for steam by 2, and so have only been given 3 marks.*

Show your working, using the equation or by any other method.

(4) Q02ci



$\Delta H^{\ominus}_r = -75 + -484 + -396 + 0 = -955$

$\Delta H^{\ominus}_r = -75 + -484 + 396 + 0 = -163$

$\Delta H^{\ominus}_r =$ ~~-13~~ -163 kJ mol^{-1}

Lead Examiner comment: *3 marks – although an energy cycle has been included, the learner has forgotten that the enthalpy changes of formation of the reactants should have been reversed. This error has further been compounded in the last line of their working where the sign for the enthalpy change of formation for carbon dioxide has also been reversed, which has given an answer of -163 instead of +163.*

Learners on 2 marks also tended to omit the doubling of the enthalpy of formation of steam but would also get confused with which values needed to be added or subtracted.

p: $-396 + 0 = -396$

r: $-75 + -242 = -317$

$-396 - 317 = -713$

$\Delta H^{\ominus}_r = -713$ kJ mol^{-1}

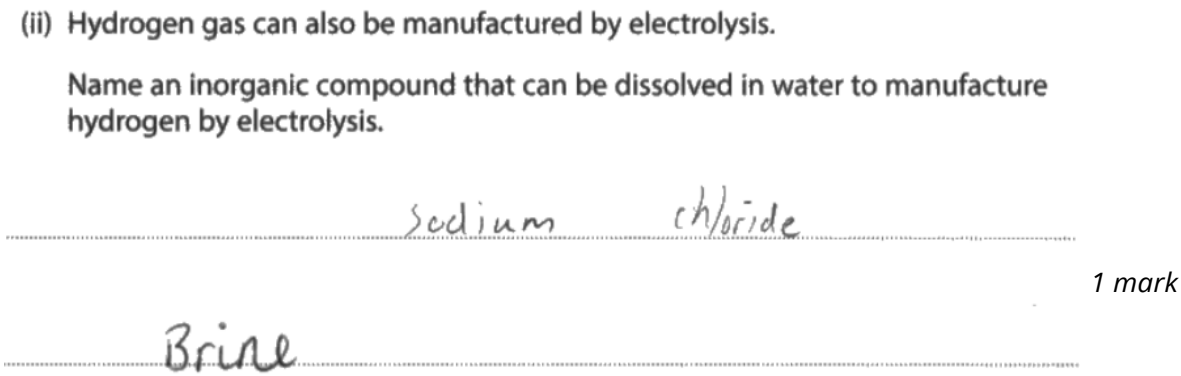
Lead Examiner comment: *2 marks – the learner has labelled the first and second lines of working as "p" and "r", suggesting that these show calculation for the combined enthalpy changes of formation for the products and for the reactants. However, the doubling of the enthalpy change for steam has been omitted. The learner has incorrectly substituted into the equation supplied and is attempting to*

summate rather than find the difference between these two values, so has introduced a second error into their working.

Q2(c)(ii)

This was a relatively straight-forward question to name an inorganic compound in water that would produce hydrogen when electrolysed, yet it did split the cohort almost equally between those that scored and those that did not.

Drawing upon the content required for this paper, the anticipated answer would be sodium chloride. Despite asking for the name of a compound, "NaCl" or "brine" were frequently observed yet were still credited.



(ii) Hydrogen gas can also be manufactured by electrolysis.

Name an inorganic compound that can be dissolved in water to manufacture hydrogen by electrolysis.

Sodium chloride

1 mark

Brine

1 mark

On the other hand, "salt" was too vague to credit as a suggestion, particularly as there was some leeway had been granted in the acceptance of other alternatives to sodium chloride. Amongst the most frequently stated alternatives to sodium chloride in solution, were hydrochloric acid and sodium hydroxide, but it was not uncommon to see potassium / group 1 salts or acidic gaseous oxides being selected.

Most incorrect responses arose because the learner had strayed from the instruction to give an "inorganic compound". Elements were often named. Chlorine was seen frequently, as well as reactive metals such as magnesium and sodium – whilst these do of course produce hydrogen with water, this showed a disregard for "electrolysis" as was referred to in the question.

It was likely that other focuses of this paper had a bearing on some learner responses. Aluminium oxide was often suggested but would not produce hydrogen even if it were soluble in water. Organic compounds were also regularly suggested – whilst this could have simply been a misread, it may also reveal that there is not a clear understanding of the difference between the inorganic and organic branches of chemistry.

Q3(a)(i)

This question was poorly answered by the majority of learners, with only about 10% of the cohort being able to name the isomer of C_4H_8 shown as being methylpropene.

(i) Name isomer **V**, using IUPAC rules.

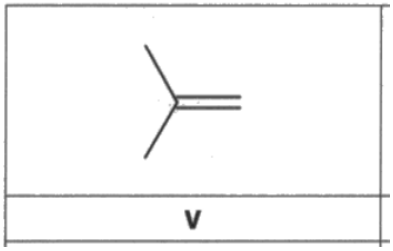
(1) 1

2 methyl - propene.

Lead Examiner comment: *1 mark – this response has been credited with the available mark. The naming follows IUPAC rules of nomenclature in the main, in spite of the hyphen and the unnecessary locant number.*

Whilst this was a simple question, to an extent the naming was made more challenging as the alkene was presented as a skeletal formula and no other names had been used to identify the other isomers. Consequently, a high level of interpretation of the formula, followed by recall of naming conventions was required.

A number of learners were able to recall that four carbon atoms should mean that the prefix was "but_", and so gave answers such as butene, but-1-ene or but-2-ene. However, this isomer was clearly an alkene with three carbons in the longest chain and a branch, so the answer needed to take this into account. In general though, IUPAC naming conventions were revealed not to be well understood by learners, with many answers showing little logic or recall of how to name hydrocarbons.



(i) Name isomer **V**, using IUPAC rules.

2,2 methyl propane.

2methyl ethane

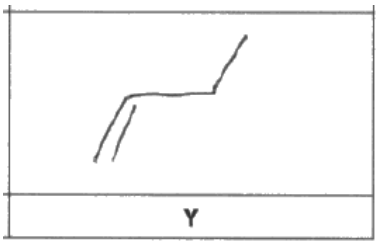
But-2-ene

2-methylpentene

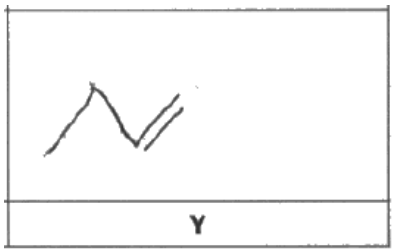
Lead Examiner comment: *0 marks – a selection of incorrect names given by learners for the skeletal formula of isomer V.*

Q3(a)(ii)

This question was better answered by learners, but still only a relatively small number were able give a correct response. About 20% of the cohort were able to draw the skeletal formula of the final isomer of C_4H_8, which was but-1-ene. Provided the diagram showed a connected sequence of "double-single-single" bonding then the learner scored the mark, irrespective of orientation or conformation of the diagram.

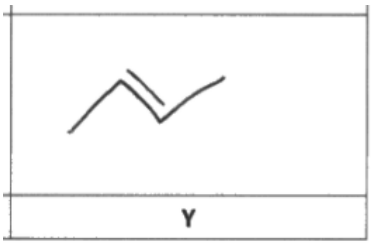


1 mark

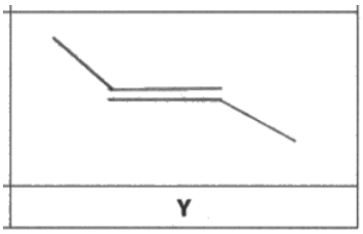


1 mark

The most common error was to draw a skeletal formula that had already been presented in Table 2, but in some way twisted or rotated to give the impression that it was different.



0 marks



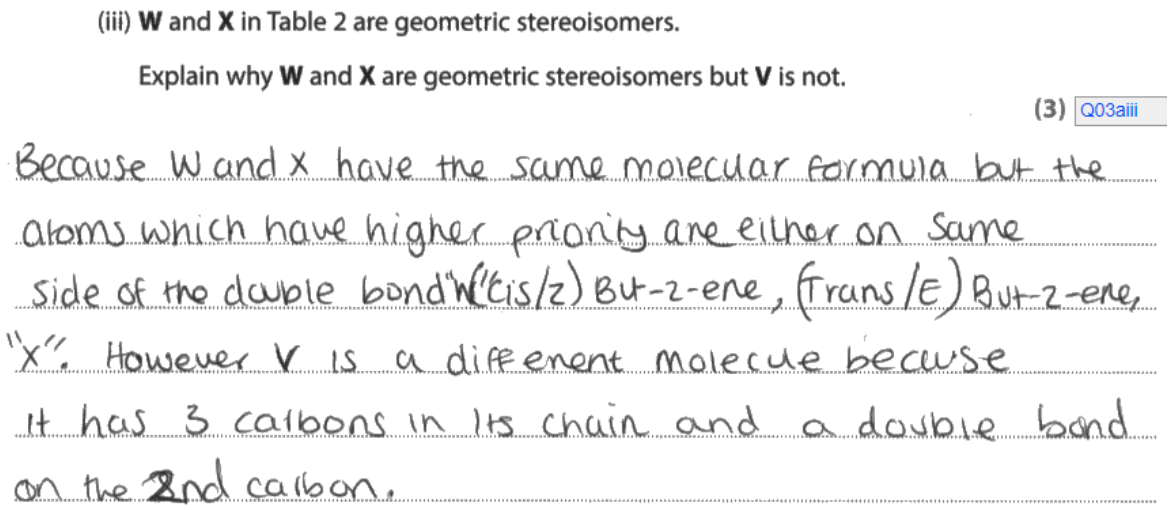
0 marks

Q3(a)(iii)

This question asked learners to explain why two of the skeletal formulae in Table 2 were geometric stereoisomers but a third formula was not. It was expected that all learners should have been able to identify a relevant common or dissimilar feature present or to be able to discuss geometric isomerism. However, most learners found it difficult to adequately express themselves in their responses and as a result failed to score any marks.

Simple statements such as "the double bond is in the same place for W and X" or "W is the *cis* isomer, X is the *trans* isomer" often worked better than over complicated descriptions. However, this could only be a starting point, and learners were generally reluctant to develop their

answers further in order to explain why the identified feature would lead to geometric isomerism.



(iii) **W** and **X** in Table 2 are geometric stereoisomers.

Explain why **W** and **X** are geometric stereoisomers but **V** is not.

(3) Q03aiii

Because W and X have the same molecular formula but the atoms which have higher priority are either on same side of the double bond "W" (Cis/Z) But-2-ene, (Trans/E) But-2-ene, "X". However V is a different molecule because it has 3 carbons in its chain and a double bond on the 2nd carbon.

Lead Examiner comment: *2 marks – this response correctly identifies W as the cis / Z isomer and X as the trans / E isomer, and makes an attempt to demonstrate an understanding that the double bond is located in a different position for isomer V.*

At the other extreme, some learners could provide a definition of geometric isomerism or state the restriction of free rotation, which required a sophisticated description. However, these good responses were often then unable to be applied to the context of the question.

Q3(b)(i)

This multiple-choice question tested whether learners could identify the formula of the alkane produced during cracking in an incomplete equation.

Over 75% of learners correctly worked out and identified that C_8H_{18} was the correct answer.

Q3(b)(ii)

Just over 40% of learners gave a valid use for a short-chain alkane. This was often shown as recognition of use as a fuel or in combustion. Sometimes a name of a crude oil fraction was given and was accepted, although this is not specifically a use.

(ii) State **one** use of short-chain alkanes.

fuel

1 mark

gasoline

1 mark

Examples of responses that were incorrect were typically uses of other compounds that had been referenced elsewhere in the paper, such as plastics, cracking and catalysis.

PVC, Polymers

0 marks

forming alkenes

0 marks

By using a catalyst.

0 marks

Q3(b)(iii)

Just under 20% of the cohort were able to specify a condition to increase the yield of alkenes in the product mixture, such as increasing temperature or pressure. A few learners correctly surmised that cracking the alkanes in the product further would also effectively increase the yield.

(iii) Give **one** way to increase the yield of alkenes in the product mixture.

Crack at a higher temperature

1 mark

crack them further.

1 mark

A wide variety of responses that were not credit-worthy were observed, and these would often give the opposite of the desired effect. The use of longer chain alkanes or "more carbon atoms" was frequently stated, as was decreasing temperature or pressure. Another popular response was the use of a catalyst – what learners believed was the catalyst was normally unspecified and catalytic cracking is more associated with increasing the yield of branched or cyclic alkanes at the expense of alkenes.

(iii) Give **one** way to increase the yield of alkenes in the product mixture.

Increase length of hydrocarbon you use as product to crack.

0 marks

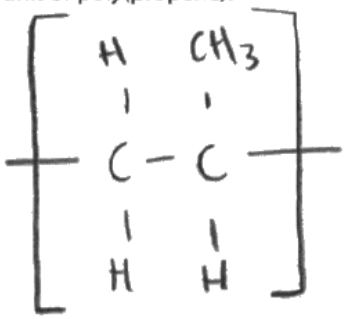
By using a catalyst.

0 marks

Q3(b)(iv)

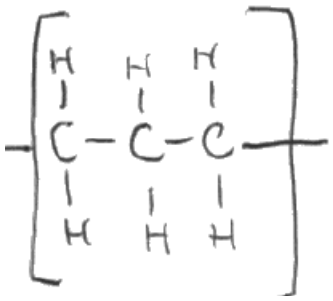
This question was relatively poorly answered by learners, with only a quarter scoring one mark or more. Good diagrams of a polymer, let alone poly(propene), were rarely encountered and the achievement of both marks was not as common as would have been expected.

Draw the repeat unit of poly(propene).



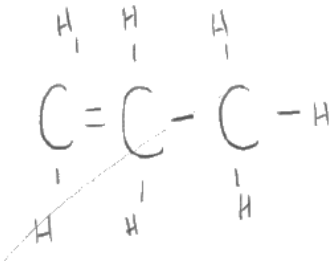
Lead Examiner comment: *2 marks – this response gains both marks. The question has only asked for a drawing of the repeat unit so the inclusion of brackets or "n" is not a requirement. CH_3 has been used, but it is also not a requirement to show a fully displayed formula so it is acceptable here.*

Where a recognisable poly(propene) unit was not drawn, 1 mark was available where the diagram showed that the molecule was no longer unsaturated and that the bonds between all of the carbon atoms were now single. There also needed to be recognition that each carbon atom had 4 bonds. This was still a challenge for the majority of learners, however.



Lead Examiner comment: *1 mark – although this response is incorrect, single bonds are shown between the carbon atoms which demonstrates understanding by the learner that there has been a change from an unsaturated structure to one that is saturated. The learner's drawing also shows understanding that each carbon atom must have 4 covalent bonds.*

Many learners did not seem to grasp the idea that the double bond was no longer present, and a worrying number of alkene molecules with pentavalent carbons could be observed.



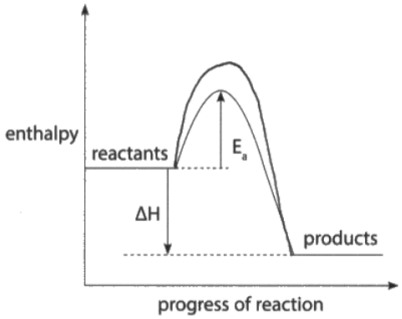
Lead Examiner comment: *0 marks – the double bond remains intact and the middle carbon atom shows 5 covalent bonds*

Q4(a)

This multiple-choice question tested whether learners could identify the exothermic and endothermic changes from a reaction profile diagram. About 43% of learners did correctly identify activation energy as being endothermic and the enthalpy change shown as exothermic. This proved to be the most popular option. Options A and D were rarely chosen, as learners had clearly recognised that the diagram showed the arrows for both processes pointing in opposite directions, and therefore could not both be endothermic or both be exothermic.

Q4(b)

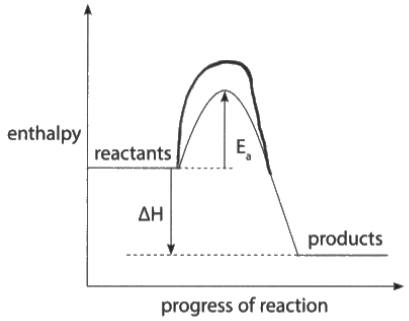
Although a relatively straight-forward question, just over half of the cohort were able to score one mark or more. Learners needed to be able to redraw the reaction profile diagram without the presence of a catalyst, which about 20% were able to do without much difficulty and so scored both of the available marks.



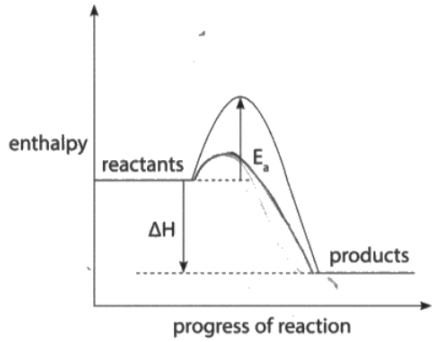
Lead Examiner comment: *2 marks – this response gains both marks. The curve has a peak higher than that of the original, with start and finish points that match the original.*

Learners that achieved only 1 mark generally lost the other mark for a variety of reasons. Probably the most frequent error was to draw a curve that was lower than the original. This was possibly due to familiarity of the effect on activation energy when a catalyst is added. Some learners would appear to attempt to draw the curve higher but would end up with something of similar height, often crossing over the curve of the original line.

Another typical reason for the loss of the second mark was poor accuracy for the start and / or end points of the new curve. A surprising number of learners managed to very clearly miss drawing their curve on the same points as the original. Accuracy of the line could also be something of an issue, as some learners would start and end their curve at some point on the first curve rather than join the specific start and end points. Occasionally, a learner would draw a curve that was not smooth and struggled to hit the start / end points in one place, and which would also forfeit the second marking point.



Lead Examiner comment: *1 mark – this response gains a mark for showing a curve that is higher, but the line has "merged" with the original. This does not show sufficient accuracy, and inadvertently suggests that the progress of the reaction is the same from this point onwards.*



Lead Examiner comment: *0 marks – this response clearly shows a sketch that is below that of the original catalysed reaction curve. Although the starting points are the same, the learner's curve has clearly not met the end point of the original.*

Q4(c)

This question asked learners to use the equations shown to explain how vanadium(V) oxide was able to catalyse the Contact process. A recognition that the equations involved redox was required. Although only the very best learners would be expected to score full marks, all learners would be expected to be able to identify the role of oxidation and reduction in the catalysis. However, only a third of the cohort scored any marks at all on this question.

It was often the case that learners did not attempt to use the equations, despite the instruction to do so. Instead, typical characteristics of catalysts were relied upon (eg speeding up the reaction, lowering the activation energy, providing a surface for the reaction, etc). As these were not points that could be established from the context of the question, such statements could not be credited.

Vanadium increases the rate of reaction and finds a different pathway to lower the activation energy.

Vanadium oxides and changs, however its then unchange in the reaction

Lead Examiner comment: *0 marks – although catalysts increase rate of reaction and offer a lower activation energy pathway, these are not characteristics that can be deduced from the equations. The response attempts to make a final point about vanadium oxide changing / not changing but the sentence is not coherent.*

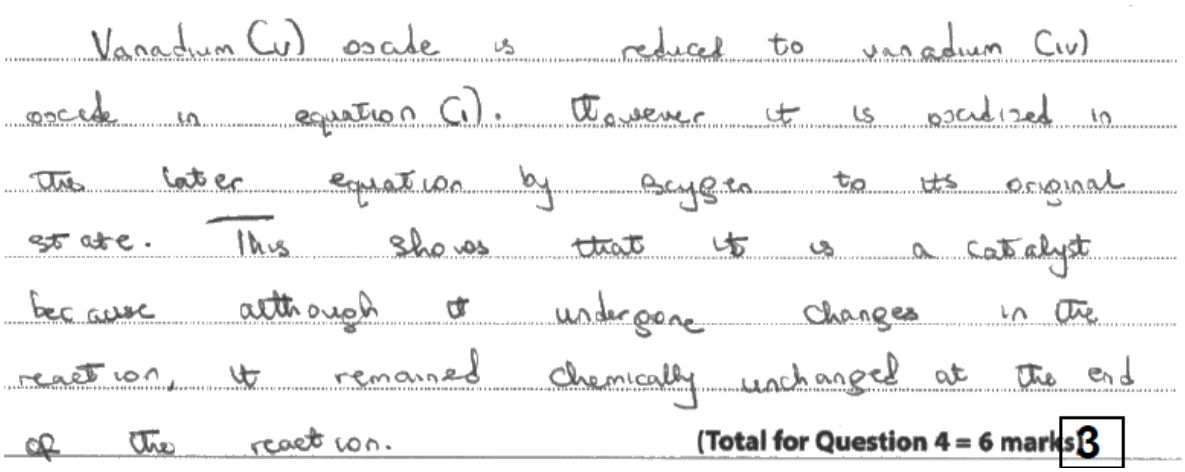
Generally, learners achieving 1 mark did so because they were able to articulate that the equations showed that vanadium(V) oxide was involved in the reaction but was restored at the end. However, this was a mark that was just as easily lost if a learner did not make themselves clear - statements such as "not used up" are ambiguous as to whether vanadium(V) oxide is in fact involved at all.
Learners which did refer to the equations more specifically were able to identify that vanadium(V) oxide was oxidising SO_2 in the first equation. It was rare to see learners refer to vanadium(V) oxide being reduced in the first equation, or to show much consideration of the second equation, let alone that vanadium(IV) oxide was being oxidised. The use of oxidation numbers was very rarely attempted by any learner in order to make a point about oxidation or reduction.

Explain how the equations in Figure 2 show that vanadium(V) oxide acts as a catalyst.

(3) Q04c

the Vanadium(V)oxide gives an oxygen to the sulfur dioxide to form sulfur trioxide. The V_2O_4 is then reacted with oxygen to form Vanadium (V) oxide once again. It is seen that the V_2O_5 is used as a catalyst due to giving the sulfur dioxide another oxygen to allow for the reaction to continue

Lead Examiner comment: *2 marks – although there is no use of the words oxidation and reduction, this response provides clear and accurate descriptions of what is happening in each equation for two marks. In order to have achieved the final mark, this reasoning would need to have been used to identify that vanadium(V) oxide had been involved but was reformed by the end of the reactions.*


Vanadium (V) oxide is reduced to vanadium (IV) oxide in equation (1). However it is oxidized in the later equation by oxygen to its original state. This shows that it is a catalyst because although it undergone changes in the reaction, it remained chemically unchanged at the end of the reaction. (Total for Question 4 = 6 marks) 3

Lead Examiner comment: *3 marks – this response has made very clear links to the equations and uses redox terminology correctly. It states that the first equation shows the reduction of vanadium(V) oxide and that the second shows the oxidation of vanadium(IV) oxide by oxygen. This chain of reasoning unambiguously supports the idea that as a catalyst vanadium(V) oxide is involved but remains unchanged by the end of the reactions.*

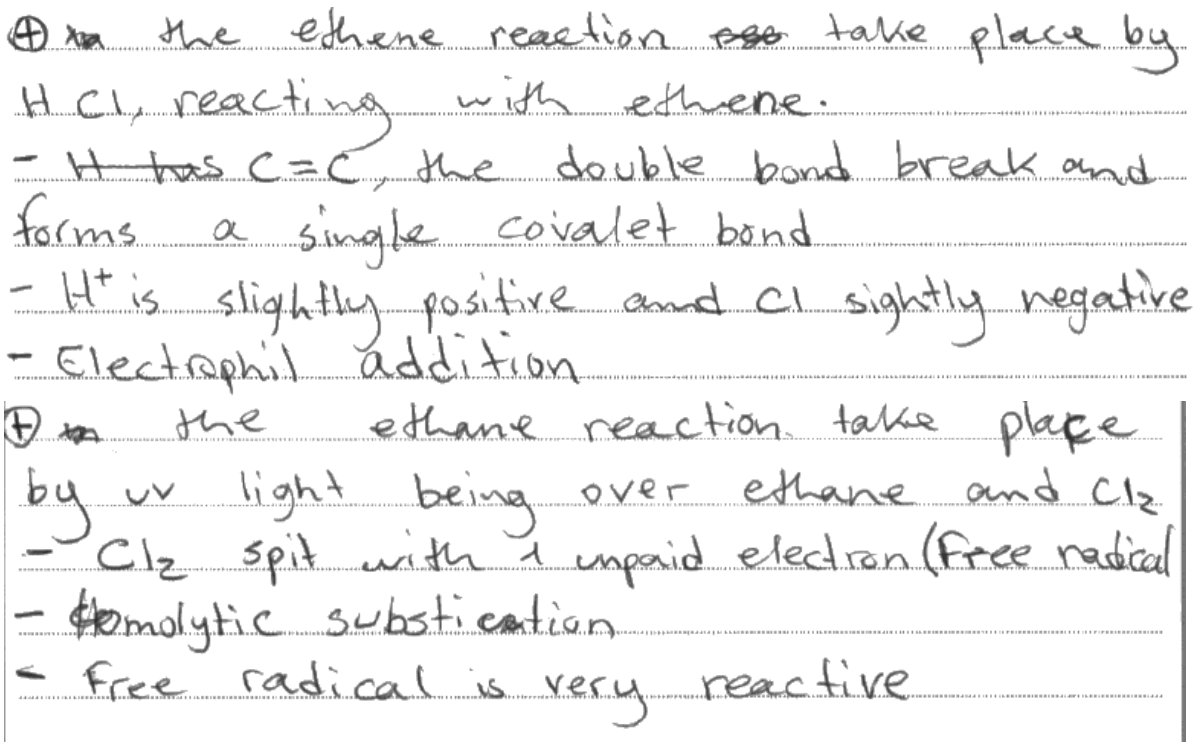
In common, with the redox experiment that was the focus of Q4 (extended response) on the January 2022 Unit 1 Chemistry paper, this would seem to be an area that needs particular attention when preparing learners for examination in this subject.

Q5

This final question was an extended response level based question and required learners to compare two different reactions to produce chloroethane.

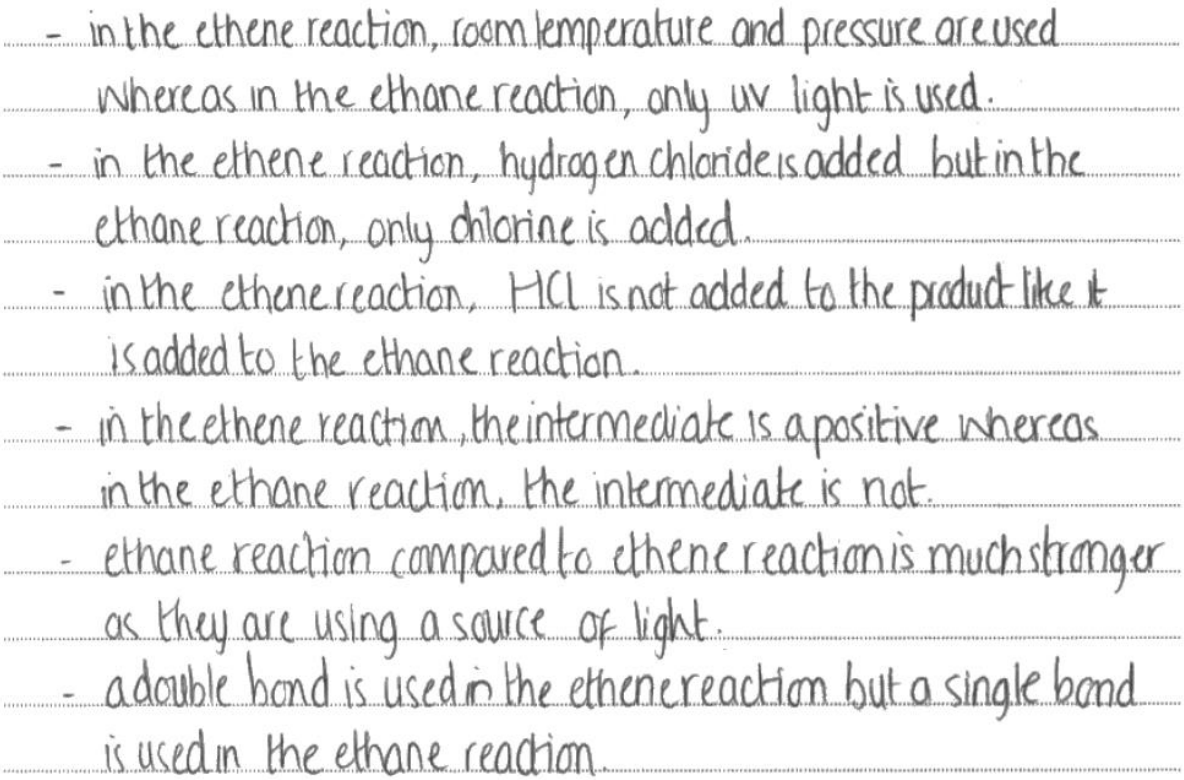
In terms of response, learners generally reacted well to the question, and it was extremely rare to see no attempt at all. In fact two-thirds of learners scored at least two marks. However, it was the approach and the depth of understanding that the learner demonstrated that determined the extent of their success.

On a basic level, many learners found it very easy to make comparisons between the first and second reactions, which explained engagement with the question. However, this thinking was deceptive as little credit would be received if there was no obvious attempt at framing the answer as a comparison. Many learners made use of conjunctive phrasing such as "but", "and" or "whereas", but some attempts stretched these acceptable conventions, by offering separate sentences or even paragraphs, which ran the risk of seeming unrelated.


+ the ethene reaction take place by
HCl, reacting with ethene.
- H has C=C, the double bond break and
forms a single covalet bond
- H+ is slightly positive and Cl sightly negative
- Electrophil addition
+ the ethane reaction take place
by uv light being over ethane and Cl2
- Cl2 spit with 1 unpaid electron (free radical
- Homolytic substication
- Free radical is very reactive

Lead Examiner comment: *Level 1, 1 mark – this response offers two distinct sections and does not adopt a structure that allows any direct comparison of the points. The points made are brief and lack clarity, in spite of signs of deeper understanding than just reiteration of information that was already provided in the context.*

Another temptation facing learners was to simply restate what was already established in the context and in the equations. For example, naming the different hydrocarbons in each reaction or stating the different conditions would not demonstrate any knowledge beyond what was already provided.


- in the ethene reaction, room temperature and pressure are used whereas in the ethane reaction, only uv light is used.
- in the ethene reaction, hydrogen chloride is added but in the ethane reaction, only chlorine is added.
- in the ethene reaction, HCl is not added to the product like it is added to the ethane reaction.
- in the ethene reaction, the intermediate is a positive whereas in the ethane reaction, the intermediate is not.
- ethane reaction compared to ethene reaction is much stronger as they are using a source of light.
- a double bond is used in the ethene reaction but a single bond is used in the ethane reaction.

Lead Examiner comment: *Level 1, 1 mark – this response offers a comparison but only offers points that are already established in the context and in the figures. There is little in the way of understanding, such as the use of specialist terminology eg the type of intermediates or the type of reaction.*

If learners built upon basic observations with interpretation or their own knowledge, then they would begin to move from Level 1 and into Level 2. Typical inferences would include:

- differences in the structure of the hydrocarbons (ie presence of double bond and single bonds, or the pi and sigma bonds present)
- how the different conditions were important (ie provide energy for bond breaking or initiating a reaction)
- differences in the products (ie identifying the more efficient reaction, or identifying byproducts and their use / hazard)

Ethane reaction: It has longes carbon to carbon chain. It's easy to break the bonds as require less energy. Chloroethane and HCl is formed in this reaction. It is more stable. Ethane has a single bond meaning it only has sigma bond, which is stronger than pi bond.
Ethene reaction: It has shortest chain and the carbon to carbon are attracted by more election in the middle. Requires more energy than ethane. Carbon to carbon is strongly attracted by the nuclei. It's hard to break short length. Ethene is has double bond, which has a sigma and a pi bond. pi bonds are easy to break as requires less energy.

Lead Examiner comment: *Level 1, 2 marks – the response considers the reactions in separate paragraphs so runs the risk of not being a comparison. However, there are sentences that are clearly comparative eg "longer", "requires more energy", etc. The majority of aspects expected to be compared are missing (reaction type, intermediates, conditions, products).*

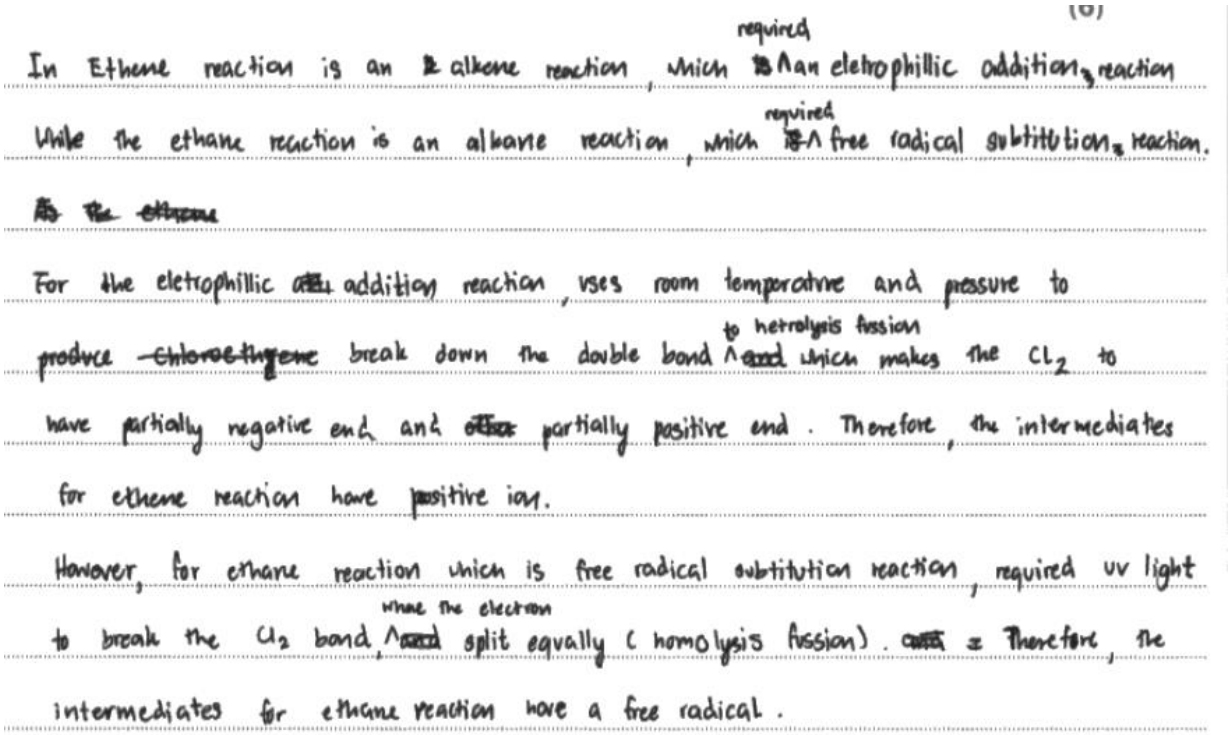
Ethene has a double bond unlike ethane which means it would take longer and require more energy to break so it would be more expensive. It requires HCl which is regularly found and the conditions are room temperature and pressure which is much easier than ethanes reaction with UV light.

Ethane has a single bond which is weaker and would require less energy therefore it would be much easier and less expensive. Unlike ethene, ethane requires chlorine gas. UV light is much more expensive conditions.

Both reactions form 1-chloroethane but the ethane reaction also has a waste product of hydrochloric acid.
Ethenes intermediate reaction forms a positive unlike ethane.

Lead Examiner comment: *Level 2, 3 marks – this response shows clear comparison which is often very basic (eg positive charge, uv light, requires HCl), but has signs of deeper understanding, such as HCl being a waste product of ethane's reaction and some comparison which is valid but not relevant. All aspects of the question are addressed, but in some cases very weakly.*

Some basic comparisons were regarded as being more insightful than others. It was pleasing to see that many learners were able to distinguish between an addition reaction and a substitution reaction, simply by inspection of the equations presented or from their revision of alkane and alkene chemistry. Similarly, recognition of the different types of intermediate and the correct use of terminology (ie carbocation, free radical) would also assist in moving a response into a higher level. Consequently, many learners were able to score 3 if not 4 marks.]



In Ethene reaction is an alkene reaction, which required an eletrophillic addition reaction

While the ethane reaction is an alkane reaction, which required a free radical substitution reaction.

For the eletrophillic addition reaction, uses room temperature and pressure to

produce ~~Chloroethene~~ break down the double bond to heterolysis fission which makes the Cl_2 to

have partially negative end and partially positive end. Therefore, the intermediates

for ethene reaction have positive ion.

However, for ethane reaction which is free radical substitution reaction, required uv light

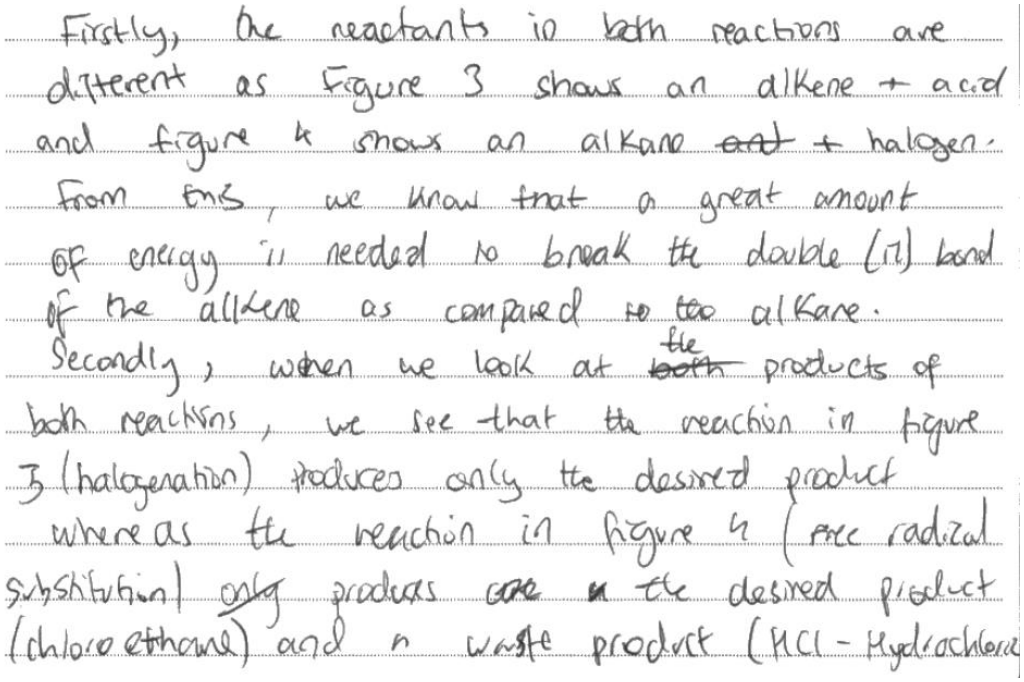
to break the Cl_2 bond where the electron split equally (homolysis fission). Therefore, the

intermediates for ethane reaction have a free radical.

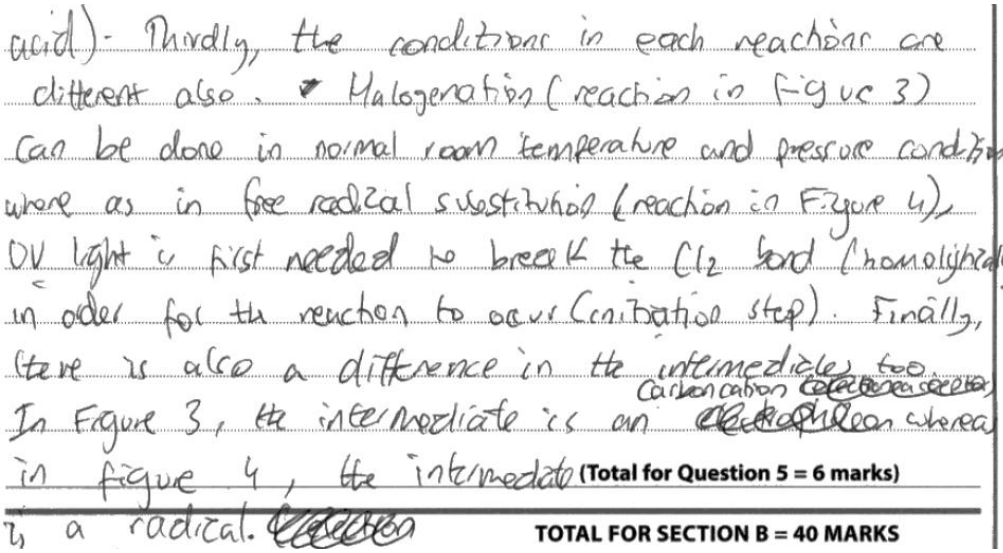
Lead Examiner comment: *Level 2, 4 marks – this response compares the two reactions in paired sentences, and most aspects of the question are addressed. An examination of the mechanism has helped and hindered the response. Differences in intermediates, bonding and bond fission are covered, but this has led to mistakes such as identifying Cl_2 as the reactant in each.*

Indeed some responses were very detailed, to the extent that full mechanisms for both reactions were drawn or described. Unfortunately, rather than add value to an answer, this approach tended to detract from it as the learner had lost sight that they had been asked to compare and went into full explanation mode. It was rare that a response showing or describing mechanisms, correctly or otherwise, actually made comparative links between the two reactions. Detailed consideration of mechanisms was not required of the question and would have been very challenging where attempted. Responses with mechanisms often achieved no better than a level 2 score, only very occasionally getting in to level 3.

The awarding of 5 or 6 marks was a rarer occurrence. As indicated, achieving a level 3 score did not simply rest upon exhibiting good knowledge or understanding but consistently using this to expand upon the points of comparison. In most responses, this could be observed on one or two points rather than the majority of points. Another feature often overlooked by learners in their comparisons was that, aside from the chloroethane product previously mentioned in the context, no other similarities were identified. This meant that responses did not fully meet the definition of comparison as found in the *Key terms used in assessment* section found at the end of the Unit 5 specification. (*"The answer must include at least one similarity and one difference."*).



Firstly, the reactants in both reactions are different as Figure 3 shows an alkene + acid and figure 4 shows an alkane ~~and~~ + halogen. From this, we know that a great amount of energy is needed to break the double (π) bond of the alkene as compared to the alkane. Secondly, when we look at ~~both~~ the products of both reactions, we see that the reaction in figure 3 (halogenation) produces only the desired product whereas the reaction in figure 4 (free radical substitution) only produces one of the desired product (chloroethane) and a waste product (HCl - Hydrochlor


acid). Thirdly, the conditions in each reaction are different also. Halogenation (reaction in figure 3) can be done in normal room temperature and pressure conditions where as in free radical substitution (reaction in Figure 4), UV light is first needed to break the Cl_2 bond (homolytically), in order for the reaction to occur (initiation step). Finally, there is also a difference in the intermediate too. In Figure 3, the intermediate is an carbocation whereas in figure 4, the intermediate is a radical.

(Total for Question 5 = 6 marks)

TOTAL FOR SECTION B = 40 MARKS

Lead Examiner comment: *Level 3, 5 marks - the response compares the two reactions in single sentences, often with an expansion, and uses terminology well such as carbocation, free radical and types of bond fission. All aspects of the question (reactants, products, intermediates, reactions, conditions) are touched upon. However, the comparison focuses on differences - there should be more evidence of similarities to make this top of the level.*

Summary

Based upon performance within this paper, learners should:

- Be able to balance equations, including ionic equations, and describe amphoteric behaviour (A1).
- Be able to relate ionic bonding and structures (eg aluminium oxide) to physical properties, such as melting point (A1).
- Understand how a catalyst functions using reduction and oxidation (A1).
- Be able to name organic molecules using IUPAC nomenclature (A2).
- Be able to recognise organic compounds from their skeletal formulae and to be able to draw skeletal formulae (A2).
- Understand geometric stereoisomerism and the features in alkenes that allow for it to occur (A2).
- Know the conditions which favour different types of products from cracking (A2).

- Be able to draw structural formulae for different polymers (A2).
- Know values for standard conditions of temperature and pressure (A3).
- Know the definition of the standard enthalpy change of formation and understand why this is 0 kJ mol^{-1} for elements (A3).
- Be able to draw reaction profile diagrams accurately, with and without a catalyst present (A3).
- Be able to identify substances being reduced and oxidised in chemical equations, within the subject across Unit 1 and Unit 5.
- Understand that “compare” requires similarities and differences between reactions (or other items) and provide expansion of these points.
- Practice questions of 3 or more marks that test understanding and develop reasoning skills. For these questions, learners should begin with identifying the relevant feature and what causes it eg the high melting point of aluminium oxide is caused by its ionic structure and bonding, the position of a double bond in an alkene and its importance to geometric isomerism, etc.
- Examine information presented in a question carefully, as this often provides access to a mark for making an observation or a comparison eg the use of vanadium(V) oxide as a catalyst in an equation shows reduction, the reactions of ethene give a carbocation intermediate whilst those of ethane give a free radical, etc.

Individual Questions

Physics

Q1

This question tested knowledge and understanding of section C3 of the specification. Learners were expected to use their knowledge of key ideas and definitions to answer a series of short questions. These tested knowledge of some of the terms in section C3 of the specification.

Q1(a)

Learners were generally able to provide at least one feature of turbulent water flow. Most struggled to give a second feature. The most popular responses related to the flow being chaotic or random, and others wrote about eddies and layers of water mixing or crossing. If learners had written two of these, they would have scored both marks. Many learners described the photograph and wrote about the water rubbing on the rocks of that the water flow was forceful, these did not score marks.

Q1(b)(i)

This was the first multiple choice question on the paper. Slightly more than half the cohort got this question correct. Many thought that the correct answer was in the widest part of the pipe (answer D) rather than the narrowest (answer B).

Q1(b)(ii)

This multiple choice question was a challenge to many learners, few were able to give the correct answer D. Many wrote B, thinking that narrow pipes give high pressure. The relationship between fast fluid flow and low fluid pressure was not well understood by most learners.

Q1(b)(iii)

Learners were asked to add an X to Figure 2 showing where the viscous drag in the pipe was greatest. More than half of the learners were able to correctly identify a region in the pipe.

Q1(b)(iv)

This question was not well answered. Many learners drew arrows in what appeared to be random directions, many also drew their arrow correctly parallel to the water flow, but in the wrong direction.

Q1(c)

The final section of the first question was an explanation of why liquids flowed faster on a hot day. The question gave a clue as to what learners had to write about by stating answers should refer to the change in viscosity. The response below gained all three marks.

(c) A learner notices that honey flows faster when poured on a hot day than when poured on a cold day.

Explain why the honey flows faster on a hot day.

Your answer should refer to the change in viscosity.

(3)

Honey flows faster on a hot day because the temperature of the honey increases. When temperature increases molecules of honey moves faster and the kinetic energy of the molecules increases which decreases the viscosity. Honey flows slower on a cold day because the temperature and the kinetic energy of the honey molecules decreases and molecules moves slower. This act increases viscosity of honey and it flows slower.

Lead Examiner comment: *The learner has correctly stated that viscosity is reduced and then gives the first two expansion points from the mark scheme. Answers scoring full marks were not often seen. In many cases learners were able to score one mark for identifying that the viscosity reduced.*

This response scores no marks

Your answer should refer to the change in viscosity.

(3)

The viscosity changes as the honey becomes hotter causing it to melt. When its hotter the particles move more freely.

Lead Examiner comment: *The learner has identified that the viscosity is reduced, only stating the stem of the question. The learner has then gone on to state that the particles move more freely, which also did not score as this is not specific enough. The learner needed to consider the attraction between the particles and their ability to slide across each other. Many responses were similar to this.*

Q2

This question tested section C1 of the specification in a pair of calculations relating to the use of the relationship W = FΔ x and the idea of efficiency. The question started with a unit conversion question.

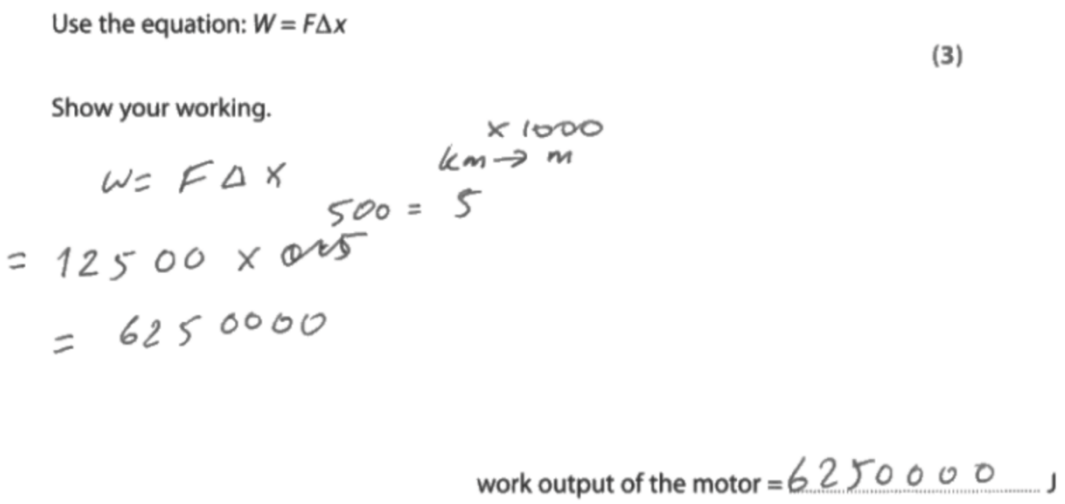
Q2(a)

Learners were asked to convert 45kW to W. Many learners were able to do this thus scoring the mark for an answer of 45000W. A fair number gave answers such as 4500W or 0.45W.

Q2(b)(i)

Many learners were able to score at least one mark in this item. The mark that was scored was generally for substitution into the given equation. Many learners struggled to convert the distance given in the question, 0.5km to m. This resulted in just one mark being lost if the rest of the calculation was correct.

This response scored full marks:


Use the equation: $W = F\Delta x$

(3)

Show your working.

$W = F \Delta x$

$500 = 5$ (km → m, × 1000)

$= 12500 \times 0.5$

$= 6250000$

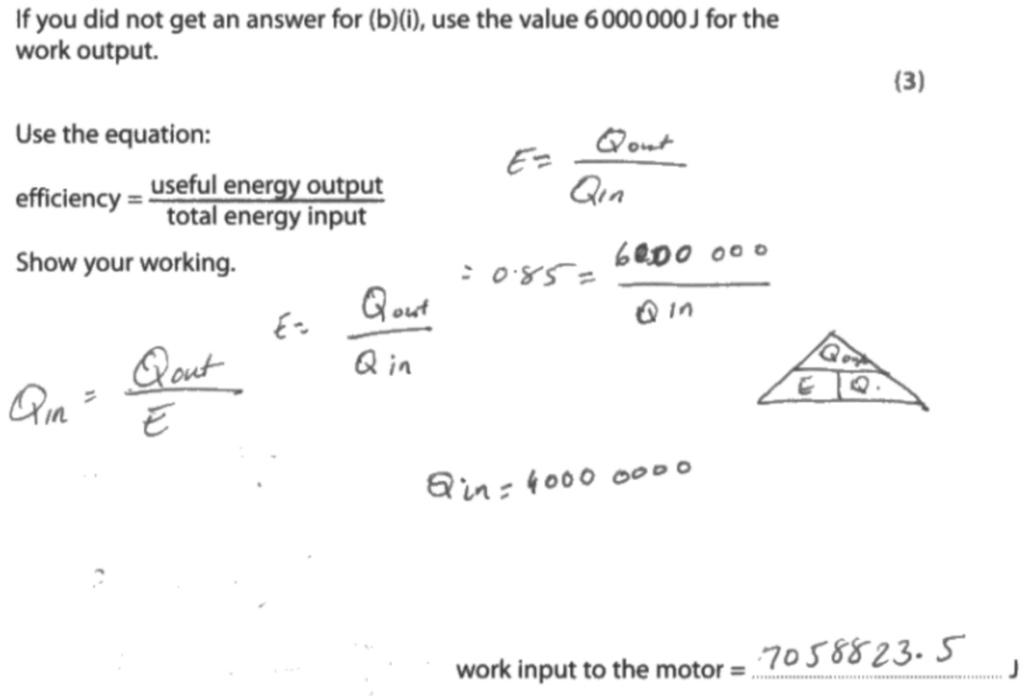
work output of the motor = 6250000 J

Lead Examiner comment: *The learner has shown the conversion from km to m and then gone onto substitute and evaluate an answer.*

Q2(b)(ii)

Learners found this part of the question harder. A correct answer required the learner to not only substitute into the equation, but also rearrange the equation to make the work input the subject of the equation, before evaluating. Many learners found the algebra required to rearrange the equation a challenge. Marks could still be scored; however, marks were lost as a result of this step being incorrect. A common error was a rearrangement that was upside down. Learners had a choice in the useful energy output they used in the equation. They could either use 6250000 or whatever incorrect response was obtained in Q2bi for an error carried forward (ecf). In addition, learners could use the value 6000000 from the first part of the question. Any of these used correctly in this part of the question scored full marks.

Lead Examiner comment: *This example shows 6000000 being used rather than the answer from Q2(b)(i). It scored full marks.*



If you did not get an answer for (b)(i), use the value 6 000 000 J for the work output.

(3)

Use the equation:

efficiency = useful energy output / total energy input

Show your working.

$E = \frac{Q_{out}}{Q_{in}}$

$0.85 = \frac{6000000}{Q_{in}}$

$E = \frac{Q_{out}}{Q_{in}}$

$Q_{in} = \frac{Q_{out}}{E}$

$Q_{in} = 4000000$

work input to the motor = 7058823.5 J

Q3

This question covers parts of section C1 in the specification, in particular the ideas of thermal capacity, thermal equilibrium, the structure of matter in a liquid compared to a solid and a calculation on a change of state.

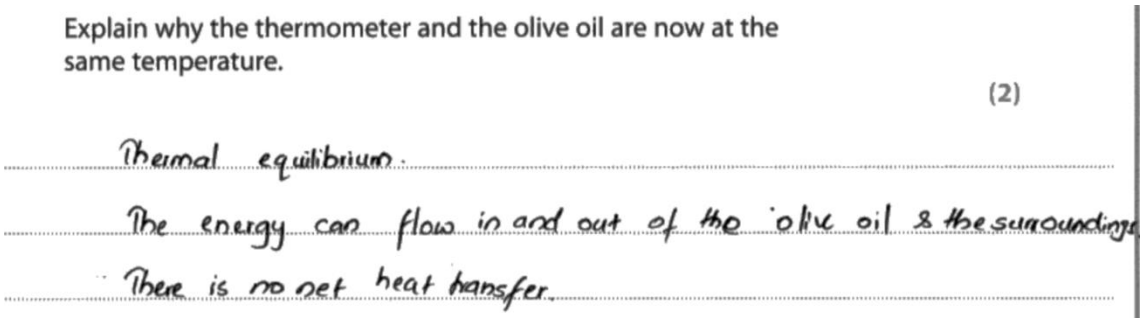
Q3(a)(i)

This multiple choice question was challenging to learners. It required learners to read the stem of the question carefully and identify that the only difference between the two beakers of oil was the volume contained and hence the mass of oil. All other properties remained the same. Many learners gave answer B, (kinetic energy), however the stem of the question clearly stated that both beakers were at the same temperature. The only difference was the thermal capacity, as there was twice as much of the oil in one beaker compared to the other.

Q3(a)(ii)

This was a very badly answered question. Many learners did not score at all. Some were able to identify that the thermometer and the oil were in thermal equilibrium, but they could not explain what that meant. Very few scored the second point.

This response scored both marks



Explain why the thermometer and the olive oil are now at the same temperature.

(2)

Thermal equilibrium.

The energy can flow in and out of the olive oil & the surroundings

There is no net heat transfer.

Lead Examiner comment: *The learner has stated that there is thermal equilibrium and then gone on to give expansion to that. This learner has written that there was no net energy transfer as well as state that the energy flows both ways.*

Many scored no marks and gave an answer relating to room temperature, such as this

Explain why the thermometer and the olive oil are now at the same temperature.

(2)

Because they are both at room temperature.

Lead Examiner comment: *The learner has introduced room temperature without considering the energy interchange between the thermometer and the oil.*

Q3(b)(i)

Learners were asked to describe the motion and arrangement of particles before and after freezing in a sample of oil. This was a four mark question that was structured to enable access to as many learners as possible. Despite the structuring learners scored poorly. Most learners less than two marks of the four available.

This response scored all four marks:

Describe the motion and arrangement of the molecules in the olive oil before freezing and after freezing.

(4)

Before freezing

The molecules could move freely and easily around each other as the olive oil has a low viscosity. The molecules will have also been arranged randomly will small spacing between them.

After freezing

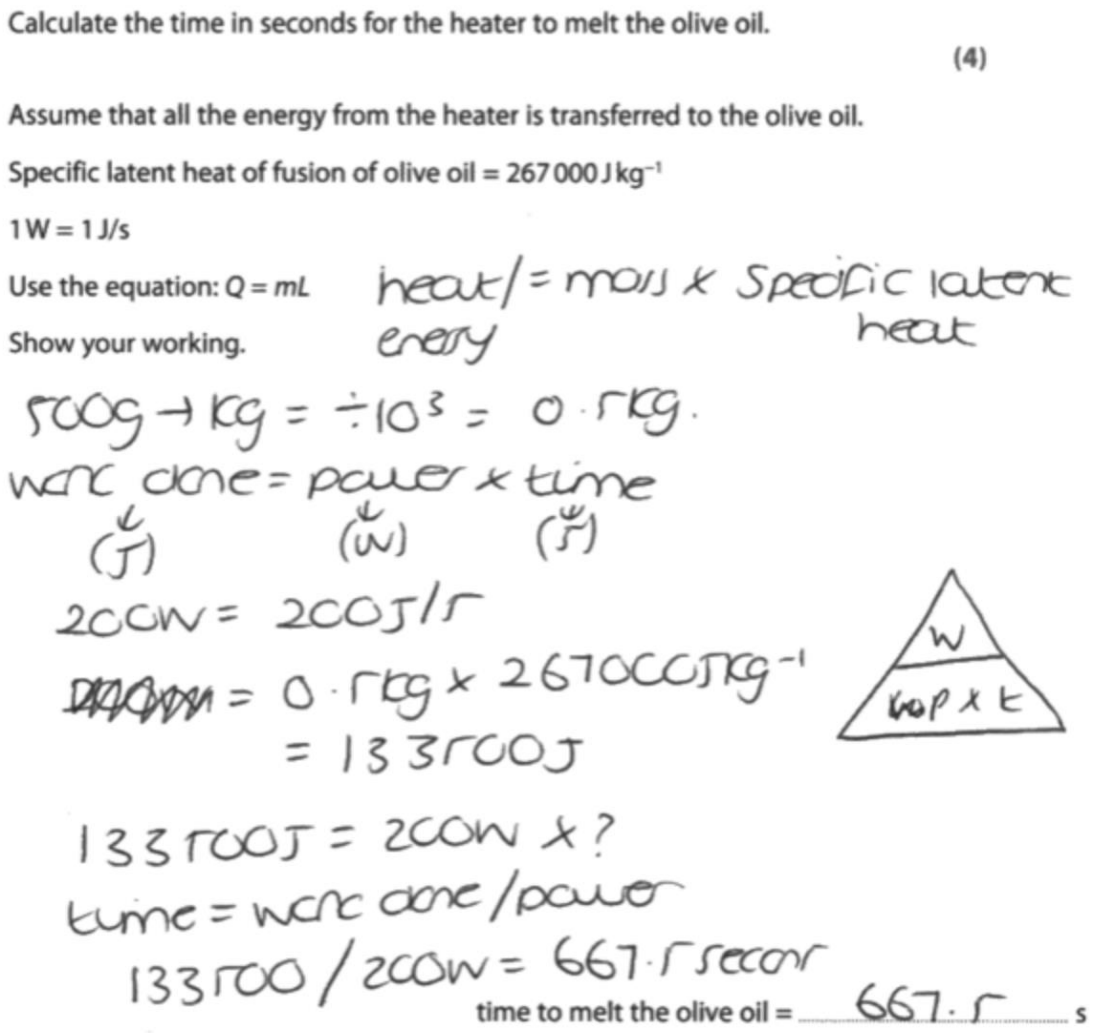
After freezing the molecules will be kept in one constant position and they wont be able to move freely around eachother. Also, the spacing between the molecules will have decreased

Lead Examiner comment: *The learner has given the first two marking points in the 'before freezing' section of the mark scheme. In the 'after freezing' section of the mark scheme the learner has given the first and third marking points. Answers of this calibre were rare. Where one mark was scored it was usually for the stating at after freezing the molecules were only able to vibrate. The structure did help learners access the question up to a point, the detail required for both marks in both sections was a greater challenge to most learners.*

Q3(b)(ii)

This calculation question testing use of the specific latent heat of fusion equation was able to gain marks from most learners. Again, this equation required a conversion from 500g to 0.5kg for the mass of oil. This point was not scored by great numbers and often resulted in learners losing a mark whilst getting the rest correct.

This response scored all four marks


Calculate the time in seconds for the heater to melt the olive oil.

(4)

Assume that all the energy from the heater is transferred to the olive oil.

Specific latent heat of fusion of olive oil = 267 000 J kg^{-1}

1 W = 1 J/s

Use the equation: $Q = mL$ heat/= mass x Specific latent heat

Show your working. energy

500g → kg = ÷10^3 = 0.5kg.

work done = power x time

(J) (W) (S)

200W = 200J/S

= 0.5kg x 267000Jkg^{-1}

= 133500J

W

VxP x t

133500J = 200W x ?

time = work done/power

133500 / 200W = 667.5 secon

time to melt the olive oil = 667.5 s

Lead Examiner comment: *The learner correctly used the mass in kg in the equation. A substitution into the given equation was required, no rearrangement, however some learners did do this. The answer from the substitution then needed to be divided by the energy supplied by the electric heater to give the final answer of 668s. Some learners then went on to convert this time to minutes and seconds. Steps beyond 668 seconds were ignored. Many learners multiplied 200 by their answer from the first part of the calculation and obtained an answer, this answer was still able to obtain some marks for the correct portions of the calculation. The correct use of algebra and understanding what the symbols mean in the given equations remains a challenge for many learners. In this example no rearrangement was required, yet many did so it seems expecting that this is always a part of a calculation. Many learners were unable to differentiate between the meaning of Q and L in the given equation.*

Q4

This question tested section C2 of the specification. The questions asked about the meanings of words, the concept of elastic hysteresis, the use of data in comparing two materials and finally in performing a calculation based on one of the equations in section C2.

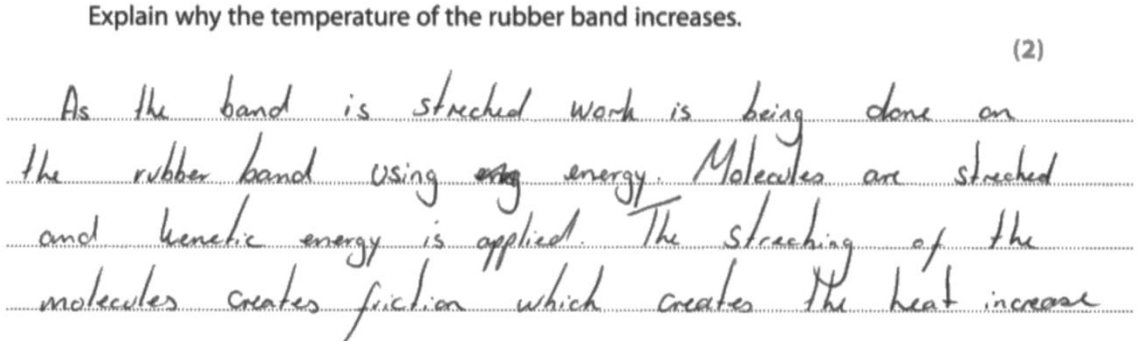
Q4(a)

This was the final multiple choice question on the paper. It was very well answered. Most learners scored this point. There is a list of terms related to materials in the specification and these appear to be well understood, they are regularly tested and always score well.

Q4(b)

This was one of the most challenging questions on the paper. Few learners were able to score any marks on this item. It was targeted at the higher end of the range of demand, even the more able learners struggled to get more than one mark. To score both marks learners had to explain that when an elastic band is stretched that there is a transfer of energy to the elastic band, or that work was done on the band. It had to be clear that the transfer/work done was to the band. General work done energy comments did not score. In addition, learners then have to indicate what this transferred energy did, or went, i.e. to increase the thermal energy store of the band.

This response scored two marks

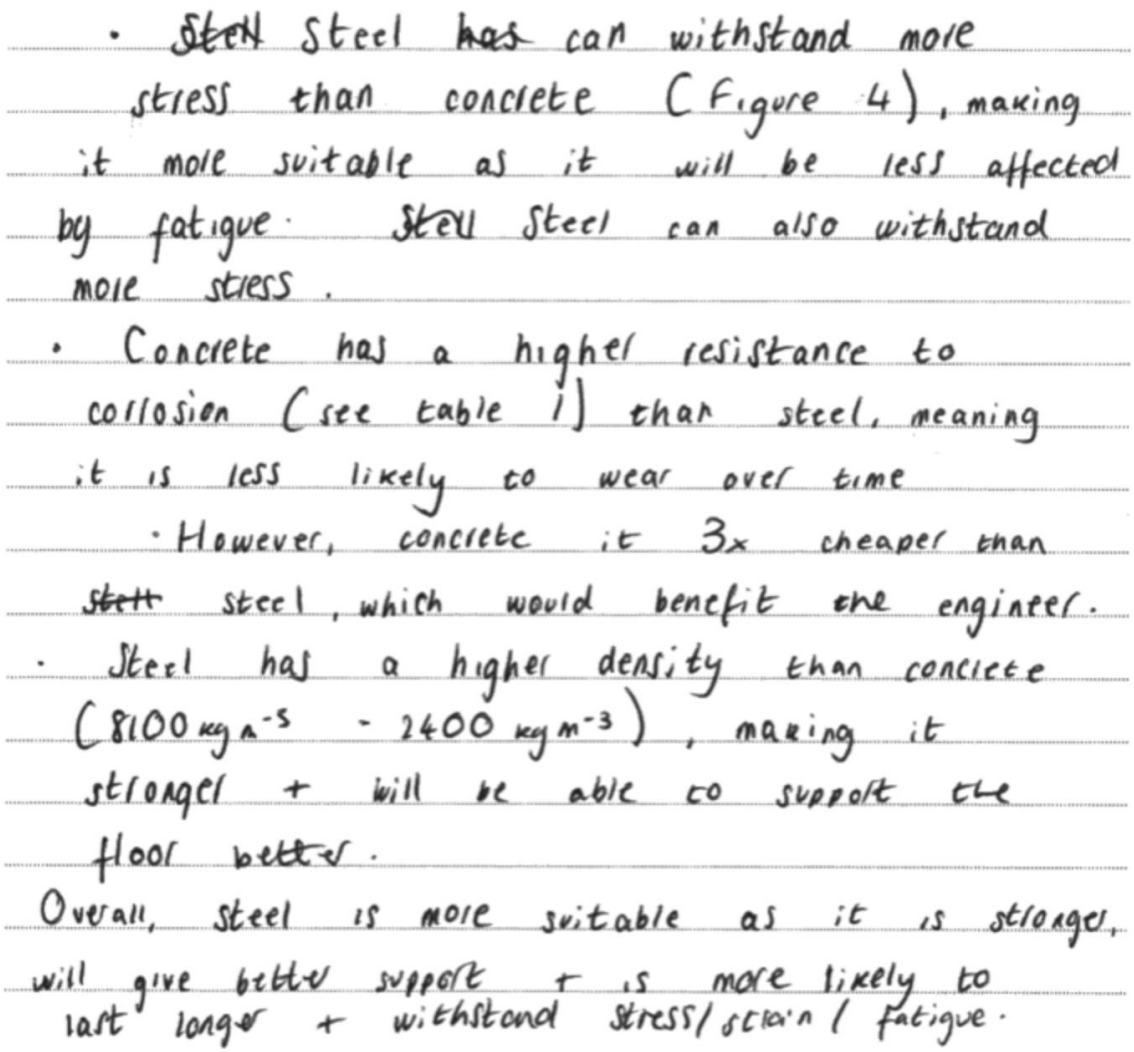

Explain why the temperature of the rubber band increases.
(2)
As the band is stretched work is being done on the rubber band using ~~eng~~ energy. Molecules are stretched and kenetic energy is applied. The stretching of the molecules creates fiction which creates the heat increase

Lead Examiner comment: *The learner has stated that work is done on the band and that the molecules are stretched in the band. The final comment was ignored.*
This final comment about stretching the rubber band hence creating friction was a common answer which when given on its own score no marks.

Q4(c)(i)

This question was the six mark levelled question. The question asks learners to discuss which of two materials, concrete or steel would be best at supporting a floor in a building. Learners were given a stress/strain graph for the two materials as well as a table of data. Learners were expected to use all the information and comment on the desirability or not of using the materials.
There was a wide range of answers and the question discriminated well giving all learners the opportunity to score marks. Responses across all three levels were seen, but as expected the higher levels and hence the higher marks were scored by fewer learners.

This response scored Level 3 Distinction at full marks


• ~~Steel~~ Steel ~~has~~ can withstand more stress than concrete (Figure 4), making it more suitable as it will be less affected by fatigue. ~~Steel~~ Steel can also withstand more stress.
• Concrete has a higher resistance to corrosion (see table 1) than steel, meaning it is less likely to wear over time
• However, concrete it 3x cheaper than ~~steel~~ steel, which would benefit the engineer.
• Steel has a higher density than concrete (8100 kg m-3 - 2400 kg m-3), making it stronger + will be able to support the floor better.
Overall, steel is more suitable as it is stronger, will give better support + is more likely to last longer + withstand stress/strain / fatigue.

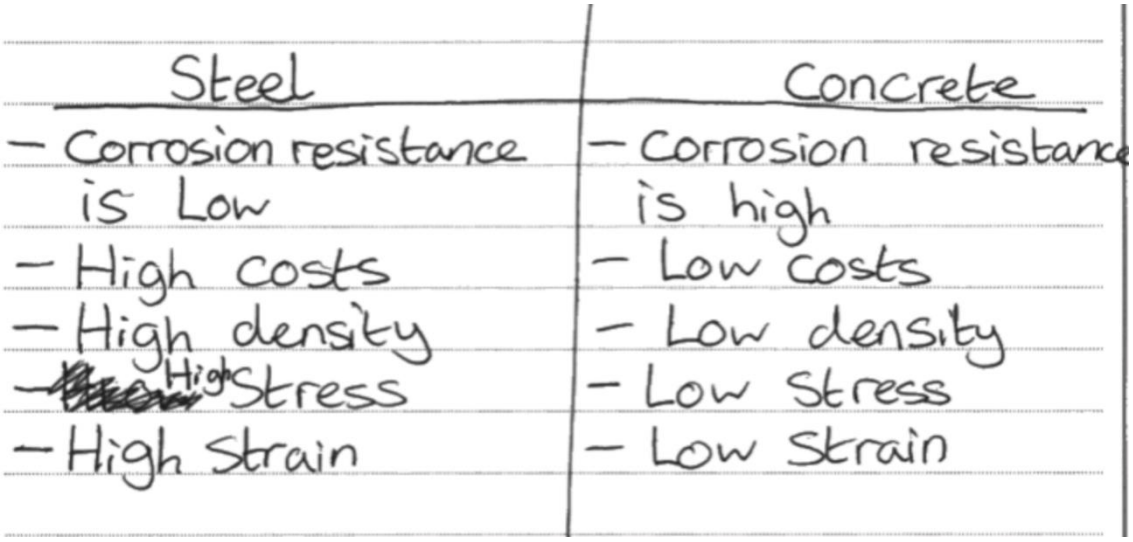
Lead Examiner comment: *The learner developed some ideas fully and has used all the information provided in the graph and table, some more than others. The learner has undertaken a comprehensive analysis and has supported their lines of argument consistently using evidence from the information supplied. The discussion is clear and well developed coherent and logical. This response therefore merits the level three mark.*

This response scored a Level 2 Merit mark

As shown in figure 4, steel shows a directly proportional relationship up until its yield point where it starts to reach deformation. This shows that steel is more suitable to support the floor as opposed to concrete because figure 4 shows that Concrete shows signs of deformation very early and has an earlier breaking point. Table 1 suggests that steel is more dense that concrete which shows better suitability for support. The cost per material shows that concrete is cheaper which could mean that its more cost suitable to support the floor but the table also shows that concrete has a high corrosion resistance as opposed to steel suggesting that steel wont corrode as easily as concrete meaning steel is most suitable to support the floor.

Lead Examiner comment: *The learner has analysed the data from the graph for steel correctly. The comments on the data from the table are weak, but there are some creditworthy points made for example relating to cost. The interpretation of the corrosion information is incorrect. The learner has provided a good analysis of the scientific information and has mostly supported lines of argument from information in the data provided and the discussion is mostly clear, coherent, and logical. This response scored four marks.*

This response scored a Level 1 Pass mark



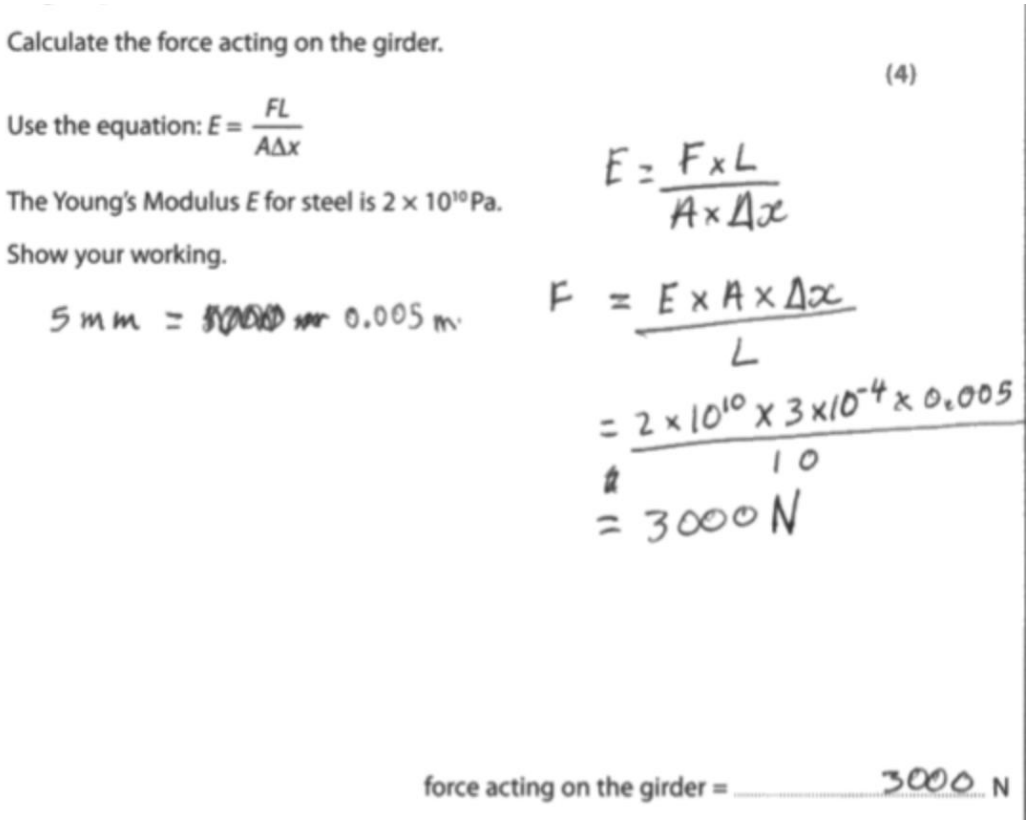
Steel	Concrete
– Corrosion resistance is Low	– Corrosion resistance is high
– High costs	– Low costs
– High density	– Low density
– ~~[illegible]~~ High Stress	– Low Stress
– High Strain	– Low Strain

Lead Examiner comment: *The learner has given information which is correct from both the table and the graph. This has not been discussed or supported in any way. There are no linkages. The response is an adequate interpretation of the scientific information. There are generic statements rather than linked information so that lines of reasoning are unsupported. There is some structure and coherence to the answer. This response scored two marks.*

Q4(c)(ii)

The final question on the paper was a calculation worth four marks. Many learners struggled with this question. A conversion from mm to m was required and many learners missed this point. As with previous calculations learners were able to score marks through error carried forward rules from wrong conversions of units and poor use of standard form. Both were tested in this calculation.

This response scored all four marks



Calculate the force acting on the girder.

(4)

Use the equation: $E = \frac{FL}{A\Delta x}$

The Young's Modulus E for steel is 2×10^{10} Pa.

Show your working.

5 mm = 0.005 m

$E = \frac{F \times L}{A \times \Delta x}$

$F = \frac{E \times A \times \Delta x}{L}$

$= \frac{2 \times 10^{10} \times 3 \times 10^{-4} \times 0.005}{10}$

$= 3000$ N

force acting on the girder = 3000 N

Lead Examiner comment: *The learner has correctly converted the extension of the girder to m from mm. The learner has then gone on to rearrange the equation in symbols before substituting in vales from the data provided and finally evaluating the answer.*

Many learners found the rearrangement of an equation with five terms a challenge in addition many learners found the correct manipulation of standard form hard. Those learners who slipped up with standard form, but with everything else correct gained three of the four marks. This question at the end of the paper was designed to be challenging and was targeted at the top end of the level of demand for this paper. It discriminated well.

Summary

- Learners should have the opportunity to use the equations listed on the final page of the examination paper and know what each of the symbols stands for in the equations.
- Learners should learn the meanings of the terms k, mm/m and g/kg which are used as prefixes to physical quantities or as units after the quantity. Learners should learn how to handle standard form confidently as well as have an idea of the approximate size of various physical quantities.
- Learners should have the opportunity to practice answers to questions with a variety of command words. Learners should have the opportunity to learn the meanings of command words. This is particularly the case in questions using commands like discuss and explain.
- Learners need to learn the basic definitions of words such as thermal equilibrium, viscosity, viscous drag and turbulence and the meaning of symbols associated with quantities such as specific latent heat of fusion.
- Learners should be given opportunities to practice answers where an arrow or other symbol needs to be added to diagram to ensure that the examiner is clear as to what the learner is intending to show.
- When answering an explain type question, learners need to make sure that they give a justification to a statement made. In many cases marks were lost in these questions as there was no justification.
- Centers should be aware that additional guidance on the content that is tested is to be found for this unit on the BTEC L3 Applied Science website via this link: https://qualifications.pearson.com/en/qualifications/btec-nationals/applied-science-2016.coursematerials.html#filterQuery=Pearson-UK:Category%2FExternal-assessments

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